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The Uncut Hank of Fiber is 10 Feet 7 Inches Long.

MANILA FIBER.—[See page 404.]

The Story of a Visit to Sir Henry Bessemer*

Recollection of the Early History of the Basic Open-hearth Process.

By S. T. Wellman, Cleveland

ABOUT 20 years ago, while crossing the Atlantic, I happened to be on the same ship with Andrew Carnegie. Shortly before landing he asked me if I would not like to meet Sir Henry Bessemer. I answered that nothing would please me better. "Well," he said, "within a few days after we reach London I will try to arrange for it," which he did by making an appointment with Sir Henry to come out to his residence at Denmark Hill in the suburbs of London. So one morning we drove out there and spent several hours with him.

Sir Henry Bessemer was a tall, fine looking man, a typical Englishman and a good talker, who liked nothing better than to talk about the early history of the steel business. He first took us around the grounds, which were very large, containing 30 to 40 acres. I cannot better describe the place than by copying the following from a London paper. The house stands on high ground, looking toward the Crystal Palace.

BESSEMER'S HOME.

"From the terrace of Sir Henry Bessemer's house the distant view is singularly pleasing and essentially English in its unhidden sylvan character. The foreground of the picture is almost entirely manufactured. Its natural slope toward the valley is perhaps generally maintained, but hills have grown where there were depressions, rocks have sprouted where there was nothing but gravel, and a lake with its feeder and outlet forms part of the purely artificial river system. Beyond the superbly terraced lawns is a sweet bit of real nature, a meadow, in which the tall rye grass, buttercups and ox-eyed daisies wave at every puff of wind, making the rich carpet red, yellow and white by turns. At the lower side of this flat meadow is a bowling green, level as a billiard table, and separated from it by a rim of ground ivy, next to which comes a triumph of landscape gardening, a great clump of rhododendrons on the rocky shore of the picturesque lake, 'Nowhere,' Sir Henry Bessemer tells his guests; 'more than 18 inches deep, an excellent depth for summer boating and winter skating, and most convenient if a child falls out of the boat or the ice gives way.' Around the lake are thick shrubberies, in which hawthorn, jasmine and honeysuckle contend with the lilac, laburnum, laurel and innumerable rhododendrons. Presently the host vanished in a bush, as if by pantomimic trick, and in a moment reappeared and led the way into a cavern filled with a magnificent collection of ferns, heated to the precise temperature, and lighted by a skillful combination of toplights and mirrors. At one extremity of this cave, lined with rocks made of brick and cement, is a waterfall pouring over a glass wall; at the other a snug little smoking room, looking over the lake, with all necessary refreshments hidden behind a rock, apparently as massive as a cheese ring, and of nearly the same outline."

The walls of these rooms, as well as the hill itself, were built of a great variety of stone. Sir Henry told us with a great deal of glee of the visit, not long before, of a celebrated geologist, who, when shown the caves and rooms, was delighted to see such a collection of rocks and was able to tell his host exactly what part of the world many of them came from, but was very much nonplused and could hardly believe him when Sir Henry told him that they were all artificial.

After wandering around the beautiful grounds as long as we wished, we were invited into the library and were entertained for two or three hours by Mr. Bessemer with his history of his early experience in the manufacture of steel.

EARLY EXPERIMENTS.

He explained that the reason he was first induced to think of an experiment with a new process of iron making was the knowledge which came to him that the French Emperor, Louis Napoleon, was seeking a material to make better artillery than was then in use. Bessemer's first idea was that he could make an improved wrought iron by blowing air through the liquid iron instead of stirring it with a rabble to bring it in contact with metallic oxides, as was the practice in the puddling furnace. To carry out this idea, he constructed a small stationary converter of fire brick. This was about 3 feet inside diameter and considerably more in height. The pipes or tuyeres entered at the side not much above the bottom. They were all connected with the blast box which encircled the converter, a pipe leading from this to the blowing engine.

The converter was covered and a hole in the side near the top was left as an outlet for the flame. When it was finished he sent to the iron store for "a ton of pig iron;" no other specification. Any old thing would do, so long as it was pig iron. Here was Bessemer's lucky day. He knew nothing at that time about the chemistry of iron or what composition was necessary in the iron to make good steel. So it was pure chance that it so happened that the iron sent to fill his order was the only brand, "Blaenavon," made in all Great Britain at that time that would have made good malleable steel under the conditions by which it was made. It was low in phosphorus and sulphur, high in silicon and contained a little manganese. So the first trial was successful in making a metal which, when tried in a neighboring iron works, rolled and hammered successfully. The bars were treated in many ways, both hot and cold, and proved to be so strong and tough that it created a great deal of interest in all who saw it.

Mr. Bessemer said that if the steel had been made from any other brand of iron made in Great Britain, the result would surely have been such a worthless metal, brittle and rotten at all temperatures, that he would have abandoned the experiment at once. Surely it was a lucky chance that sent him to that iron dealer.

FIRST LICENSES SOLD.

Bessemer immediately took out patents on the process and as the British Society met soon after at Cheltenham (this was in 1856), he prepared a paper on the new process, which was read, and exhibited his samples. The paper created a great deal of excitement among the iron makers present, so much so that before the meeting closed he sold shop rights to the five leading iron works of England for the sum of £10,000 each, and went back to his home with the cash. As I have said before, very little was known of the chemistry of iron and absolutely nothing of steel.

As soon as possible all of the licensees of the new process built converters at their own works and tried to make steel from their own iron, but every one of the experiments was a dismal failure, and not a pound of malleable steel could be made. It was, of course, a great surprise to every one, including Mr. Bessemer. He was branded as a trickster and thief, and every effort was made to get the money back, but he was not the kind of man to deceive. He knew that there must be a reason why one kind of pig iron would make good steel and another brand would not, and he determined to find out the reason, but it would take time and money to do it. Luckily he now had both, so he went to work. He found a chemist who thought he could work out a method for finding the composition of the various samples. He succeeded in demonstrating that the good steel was low in phosphorus and sulphur, while the bad was very high in both these elements.

THE FIRST BESSEMER IRON.

Mr. Bessemer kept all this knowledge to himself, and went quietly to work to build a small converting plant with which to experiment and to demonstrate the process. Meanwhile, he went to work with the help of some friends to buy back the shop rights which he had sold, as he had formed very much higher ideas as to the value of his process than at first. This he succeeded in doing, paying for one right £10,000 and for another £20,000, or twice as much as he had received. When his experimental plant was ready he made a journey to the West Cumberland district to arrange for some iron. The ores from which the first iron he had used was made had come from there, and he had discovered that it and the West Cumberland ores were low in phosphorus, so he ordered some iron made from that ore. It was duly received at the works and the first steel in the new plant was made, but very much to his surprise it was no better than that made by his licensees. Then he had the iron analyzed and found it high in phosphorus. He could not understand how this could happen when the ore was so free from this bad element, so he journeyed back to the West Cumberland furnace to find the trouble if possible.

In walking around the plant with the manager he came across a large pile of black looking rock or other mineral and asked what it was. The manager told him that it was the flux he used. Well, what was it? Why, it was puddle furnace cinder; this he knew must contain a large percentage of phosphorus; he had found the cause of the trouble sure enough. "Why do you use it?" he asked. "Why, to make the furnace work smooth and the iron fluid." The result of the visit was an order for more iron to be made from straight ore with no puddle cinder. The order was filled and was billed as "Bessemer iron," a trade name which it bears to this day.

NO LICENSES BUT ROYALTIES.

The next experiment was successful and the steel turned out was all right in every respect and fully as good as the first trial, the samples from which were shown at Cheltenham. It was now comparatively smooth sailing for the new works and he was soon able to demonstrate that he could make uniformly good steel that was strong and tough, hot or cold; also steel of any carbonization desired, hard or soft. His old friends, from whom he had bought back the licenses, then came and demanded them back, but he said, no; the process was much more valuable than he at first supposed and he had decided not to sell any shop rights, but would license any one to use the process for a royalty of £1 per ton for rails and £2 for all other work. This royalty he insisted on and it was paid by all users of the process in England during the life of the patent.

The process very soon came into general use, as the trade was ripe for it. It was just what was wanted, particularly for rails. The old wrought iron rails were very poor and the "Bessemer steel rail" filled a long felt want; without it the great railroads of the world would be almost impossible. The first rail was laid at the Crewe Station of the London and Northwestern Railroad and wore out 23 iron rails.

MUSHET'S MANGANESE PATENT AND ITS LAPSE.

Bessemer soon found that manganese was necessary in the iron to make the steel malleable when hot in rolling or hammering, but the process of adding a carbide of manganese to this mixture was the idea of another inventor, Robert Mushet, who thus became a rival of Bessemer, and as Mushet sold an interest in the patent to one of the iron companies who were trying to get back the shop right which they had sold back to Bessemer, they used this as a lever to demand a very large royalty from Bessemer for the use of the manganese patent. Through this a great deal of bad feeling was worked up between Bessemer and Mushet. The handling and caring for Mushet's patent was left by him to one of his partners, and he, by some oversight or negligence, allowed the patent to lapse by a failure to pay the annual fees when due; so, very much to Bessemer's surprise and joy, he learned one morning that this had happened, and that Mushet's patent was public property; that he as well as all others was free to use it. Bessemer's process was useless without Mushet's invention, and Mushet ought to have made a fortune out of it, but he made nothing and died a poor man.

Several years after the lapsing of Mushet's patent, one evening there was a knock at Mr. Bessemer's door. On opening it the servant found a young woman, poorly dressed, who asked to see Mr. Bessemer. She was shown into the library and introduced herself to Mr. Bessemer as the daughter of Mr. Mushet. She said she had heard that he was a kind-hearted man. She had come of her own free will to tell him that her father and his family were very poor and suffering for the necessities of life. She knew that by the aid of her father's invention he was being helped to make a great deal of money and she thought that perhaps he would help them in their great need. The result of this appeal was that Mr. Bessemer during the remainder of Mr. Mushet's life paid him a pension of £300 per year, thus proving the truth of what the daughter had heard. It certainly was a noble act.

CHANGES IN THE CONVERTER.

Bessemer's model works soon became the mecca of the iron men of England, for here were worked out all the early problems of Bessemer steel making. The stationary converter was soon abandoned for the tipping converter, mounted on trunnions, with a removable bottom, in which were placed the fire clay tuyeres. Except in some minor details this beautifully simple piece of apparatus has remained unchanged for 50 years. The works in Sheffield still is in operation under the name of Henry Bessemer & Co. He made a large fortune from the royalties acquired in England, but comparatively little from the rest of the world.

For many years, more steel was produced by the Bessemer process than by all others put together, but now the basic open-hearth has passed it in tonnage, and it would seem that the day is not far distant when, as A. L. Holley used to predict, the open-hearth will go to the funeral of the Bessemer process. The reason for this is not hard to see. The acid Bessemer process must have pig iron low in phosphorus and sulphur, high in silicon, within very close limits; the basic Bessemer must have high phosphorus, low sulphur and silicon. The particular kind of ores necessary to make these kinds of iron are getting scarcer every year.

* From the Journal of the Cleveland Engineering Society, Cleveland, Ohio.

While for the basic open-hearth only low silicon is essential, phosphorus and sulphur can be removed by the process and much lower phosphorus and sulphur be left in the finished steel than is found in the average Bessemer.

In several works in this country a process is in use in which high silicon pig iron, also high in phosphorus, is used. Most of the silicon and carbon are blown out in the Bessemer converter, the metal being then removed to an open-hearth furnace, where the phosphorus and sulphur and the remainder of the carbon are removed and the steel finished.

BESSEMER'S ROYALTIES HIS VERSATILITY.

Bessemer was a very versatile inventor, but the bulk of his fortune was made from his steel process. The patent for this expired in 1870. During its life he received in royalties over £1,000,000. Very seldom has an inventor been so well rewarded.

One invention of his was "Bessemer gold powder," the method of manufacture of which he did not patent, but kept a secret. Only four or five workmen were employed, as the machinery was automatic. After he had made his fortune from steel, he gave the gold powder business outright to the two leading workmen who had grown old in his employ.

He was the inventor of several patents on sugar mill machinery, also of a system of furnaces using combustion under very high pressure. He spent a great deal of money on this but nothing came of it.

He only left England on one occasion, when he crossed the Channel to France. He was so terribly sick that he came near dying, but this set him to working on an idea for a steady cabin steamer. Thousands of pounds were spent in building a very large boat embodying his idea, but it was a failure and was broken up. If this had been a success he said he would have visited America; but much as he desired to come, he did not dare to take the risk.

He was always busy at something new. At the time of our visit he was working on a solar furnace, using a large number of 24-inch lenses. The rays of the sun coming through were concentrated in a small furnace, resulting in a tremendous temperature. I have never received any information as to the result of this particular experiment.

I bade good-bye to our host with regret and shall never forget the visit. I saw him but once again, just for a few moments, in London.

The Sanitary Control of Public Eating and Drinking Places*

Its Regulation By Law

By Walton Forest Dutton, M.D.

THE sanitary knowledge of the ancient Egyptians was tolerably extensive, and, gaged by the measure of those early ages, by no means unimportant. It corresponds to the reality in both the actual and chronologic points of view to consider the Jews (Moses) as creators of public hygiene.

The Egyptian priests bathed their bodies twice every day and twice every night. This was not altogether a priestly custom, for history relates that Pharaoh's daughter bathed daily in the Nile.

The ordinance of Leviticus xv, 11, was made the basis of a sanitary system of ablutions before meals, for which vessels were provided, and further, to secure against defilement in any other way, a system of washing of cups, pots and brazen vessels was devised (Hebrews ix, 9 and Mark vii, 4). In Leviticus xiii and xiv it is noted that the patients' clothing, the vessels they used and the houses they lived in were disinfected. Later St. Mark viii, 4, reads: "And when they come from the market, except they wash, they eat not. And many other things there be, which they have received to hold, as the washing of cups and pots, brazen vessels and of tables."

The rich of Greece (460 B. C.) had their private baths and the Athenians their public baths.

When in the Greek home, as guests, persons reclined comfortably at the table and water was poured over the hands and dried with individual towels. Then small portable tables were brought. After the repast was over, the tables were removed, the floor swept clean of crumbs, bones and the like, and once more water was poured over the hands. The use of knives and forks was unknown at this period, whence the custom of washing the hands and drying them on towels.

Roman laws provided no protection for the individual. In older times of Roman history, lavatrinæ or wash-houses were next the kitchen. Later, hot, sudatory, tepid, cold and shower baths were in the homes. At the end, as at the beginning of a meal, the hands were washed with scented soap. The public baths, such as the thermæ of Veleia and Pompeii and the baths of Caracalla, in Rome (217 B. C.), were masterpieces of architecture. It has been calculated that 62,000 people could have bathed any hour in the public baths of Rome, not to mention the private baths.

Hygienic measures were a part of the religious observances among the ancient Jews, as well as among the people of Assyria and India. The measures were enforced by their priests. Among the Greeks this duty was transferred to the physicians. Through the whole, the Jews enjoyed a remarkable immunity from epidemic diseases, while their Christian neighbors perished around them. In medieval and modern history, down to the present time, the filthy habits of the Christian population offered a premium for plagues of every kind. Two centuries ago the mortality of London was eighty per thousand. Until a comparatively recent date the mortality of our large cities compared favorably with the London of two centuries ago.

The gradual deviation from the sanitary ideals of Mosaic times to the beginning of the twentieth century was such as to lead to the belief that the standard of civilization was declining, instead of rising. It is not an uncommon thing to see, in the densely populated sections of our large cities, in the small towns and even in country districts, hygienic and sanitary conditions, relative to public eating and drinking places, that would put primitive peoples to shame. On a tour of inspection I saw many eating places where no provisions were made for ablutions before meals. The knives, forks, spoons and dishes (some the cat and dog had used) were rinsed, not washed, in water that had not been changed for days. Among the patrons of these eating places were whites, blacks and mongols. In another series were found eating places where provisions were made for ablutions of face and hands, but all used the same bowl, towels, soap, etc. The eating and drinking vessels were washed in pans, but no attempt was made at sterilization.

In first-class eating places provision is made for the hygienic and sanitary comfort of the patrons, yet it is the personal element that enters into the protection of the individual in the higher class places.

The standard of public drinking places may be classed in much the same way as the eating places, with this exception: even in places of the highest class, glasses and bottles are only occasionally sterilized. In lieu of the foregoing conditions I would suggest the following:

1. The enactment of laws relative to the sanitary condition of public eating and drinking places, which shall provide for (*a*) the personal hygiene of owners and employees and (*b*) sanitary precaution on the part of owners and employees.

2. The owner of each and every public eating and drinking place shall be licensed under such law, such license to continue in force as long as there is no violation thereof.

3. Any and every glass, cup, dish and other eating or drinking vessel or utensil used in any hotel, saloon, restaurant, drug store, soda fountain, or other place of public refreshment in the State shall be sterilized in steam or boiling water after being used by any patron and prior to any further use thereof in eating or drinking by any other patrons; and no such glass, cup, dish or other eating or drinking vessel or utensil after use by one patron in eating or drinking, shall be offered or be permitted to be used by any other patron without having first been thoroughly cleansed and then sterilized in steam or boiling water.

4. No person, firm or corporation shall at any time or place keep, expose, offer or prepare for sale, or shall store pending sale, any article or substance of human food or drink in any place or premises which is not, at such time, screened so as to prevent insects from having access to such article or substance; and no person, firm or corporation shall at any time or place keep, expose, offer or prepare for sale, or shall store pending sale, any article or substance of human food or drink in any place or premises unless such article or substance is pure and wholesome and entirely free from contagious and infectious bacteria.

5. No drinking vessel, used in common or to be used in common, shall be kept, exposed, provided or permitted in any railway station, public or private school, public playground, public park, public building or in any place to which the public are admitted.

6. No drinking vessel used in common shall be exposed, kept, provided or permitted in any mill, factory, railway train, ship, boat, hospital, private or public institution, public works or in any place where a number of persons are employed or assembled.

7. No table linen or coverings, towels, cloths, sponges, soap, combs or water used in common or to be used in common shall be exposed, kept, provided or permitted in any public eating or drinking place.

8. No person or persons shall be served food or drink at any public eating or drinking place until they shall have thoroughly cleansed the hands and face with soap and water, as provided for in Suggestion 7.

9. No person or persons known to be suffering from an infectious or contagious disease shall be served food or drink at or in any public eating or drinking place unless isolated from other patrons under proper sanitary conditions, in order that no other patron shall in any way be exposed or endangered in any manner whatsoever to said infection or contagion.

It may be argued that no sanitary system can supplant present conditions unless entailing great expense and inconvenience. To this I agree; but whatever is humane and promotes the progress of civilization is expedient and necessary. I would therefore suggest the following as a few of the many things that may be used: sanitary paper cups, straws, cupless attachments on faucets, sanitary systems of drinking fountains in mills, factories, stores, institutions, etc., bubbling fountains, which make cups unnecessary, paper napkins, individual towels, cloths, soap; installation of systems for rapid cleansing and sterilization of dishes, glasses, cups or other utensils, used in or about public eating or drinking places.

Most, if not all, of the State boards of health have condemned the public drinking cup. The progressive cities have passed ordinances prohibiting the use of the public cup. St. Louis has taken advanced measures to enforce the cleansing of any and every glass, cup, dish and other eating or drinking vessel or utensil used in or at any public eating or drinking place, in running water or clean water. This ordinance is a great stride in the right direction, but falls far short of the mark.

Railway companies announce that passengers do not demonstrate any great desire for individual sanitary cups. Other large corporations maintain that there is no particular benefit derived from the use of the individual cup, and further that the added expense is necessarily great. The same argument comes from the individual in respect to slot machines, paper napkins, etc.

The solution of this great problem of sanitary control of public eating and drinking places depends on the elimination of two factors—avarice and ignorance. The mercenary motive of the individual, as regards hygienic and sanitary methods, predominates over his moral obligation to himself and his fellow men. Hence the sequence of his reasoning leads to antagonism of laws respecting sanitary science, basing a great deal on the aphorism that "the Lord giveth and the Lord taketh away." The community reasons that the enactment of laws relative to the control of sanitary conditions brings on it added hardships in the form of increased tax-rate, higher cost of living, physical discomfort and infringement on its personal liberty.

The State, until a comparatively recent date, did not take marked interest in sanitary affairs. It does not at the present time consider seriously the individual. The most notable advances made by the State have been when great commercial interests were endangered. It is said that "Ignorance of the law excuses no one." Such being the case, we have one of two ways of solving a serious problem. The laws must be enacted after the Mosaic method and then enforced, which is a most plausible way, or the laws must lie dormant until the masses are educated or have reached a higher standard of civilization.

Realizing that any community that wishes to be prosperous must be healthy, sanitarians have taken the initiative in formulating laws to that end, and have accomplished more for their respective communities than has been achieved in this or any other country in the last 2,000 years. This may seem a broad assertion, but is it not true? The brilliant and noble work of Gorgas, White, Blue, Stiles, Sternberg, Wyman, Guiteras, Carroll, Lazear and associates, who forged the chain enabling the United States Government to have and to hold its many possessions, had the sanction and legal support of the Government.

* Read in the Section on Preventive Medicine and Public Health of the American Medical Association, at the Sixty-third Annual Session, held at Atlantic City, June, 1912.

Fig. 1.—Until the Introduction of Modern Machinery, All Rope was Made as Shown in the Engraving.

Fig. 2.—Compare This Modern Rope Transmission With the Ancient System Shown in Fig. 9.

The Manufacture of Manila Rope*

Its Use for Transmission and Hoisting

By C. W. Hunt

Manila Hemp.—There is the same difference in the strength of various qualities of manila fiber as there is in oak timber or other woods. The constructing engineer would select one quality of oak for wagon construction, another for mill work, and perhaps still another for sheet piling or temporary work; so should manila fiber be selected to suit the use it is to be put to. Rope used for hoisting or for transmission of power is subjected to severe usage in passing over small sheaves while under a full load. Ordinary rope chafes and grinds itself to powder in the center, while the exterior may look as though it was little worn.

Fibers.—The fibers of manila hemp are composed of very much elongated cells that look, under a microscope, like a bundle of pipes. These are of very great strength in the direction of their length, but are weak transversely, as they are not strongly cemented together. To obtain fibers of suitable size for manufacturing the rope, the stems are subdivided by machinery, which separates the cells from each other, and leaves the surface of each fiber rough and uneven, somewhat like the surface shown when pine wood is split. When made into rope these rough fibers are compelled to slide on each other in bending over the sheave while under pressure from the load.

From Knight's Mechanical Dictionary, by permission.

Fig. 3.—This Sculpture, found in a tomb at Thebes of the time of Thotmes III., the Pharaoh of the Exodus, represents the process of making ropes from thongs of leather. The material is shown by the skin hanging up in the shop. The thongs are cut by turning the piece around as the workman cuts with a knife—the same means we now use. Two coils of finished rope are shown. As the workman receded, he twisted the rope by some kind of a swivel that evidently had a weight, used both for a handle to twist the rope, and, by its weight, to prevent the rope untwisting. An assistant arranged the strands as the work progressed.

Internal Wear.—In bending a rope over a sheave, the strands and the yarns of these strands slide a small distance upon each other, causing friction, and wearing the rope internally. Open a worn-out rope by untwisting the strands, and a fine powder will be found, showing that when the rope was bent over the sheave, the strands, in sliding on each other, ground some of the fibers to powder. To obviate this difficulty, a special rope is made by lubricating the fibers with plumbago, mixed with sufficient tallow to hold it in position. This prevents internal chafing and wear. The lubricant lodges in the hollows and uneven places of the fibers, filling them up and lubricating the threads of the rope. The tallow makes the rope partially waterproof. After running a short time, the exterior of the rope gets compressed and coated with the lubricant, so that when running it looks like a rod of iron. In this condition it resists ordinary rains to a surprising extent.

Rope Manufacture.—In manufacturing rope, the fibers are first spun into a yarn about one eighth of an inch in diameter, this yarn being twisted in a direction called "right hand." From 20 to 80 of these yarns, according to the size of the rope, are then put together, and twisted in the opposite direction, or "left hand," into a strand. For a four-strand rope, four of these strands are then twisted together, the twist being again in the "right hand" direction. It will be noticed that when the strand is twisted, it untwists to some extent each of its component threads, and later, when the four strands are finally twisted together into a rope, it untwists the strands but against twists up the threads. It is this opposite twist of the threads and the strands that keeps the rope in its proper form. When a weight is hung on the end of a rope, the tendency is for the rope to untwist and become longer. In untwisting the rope, it twists the threads up, and the weight on the end of the rope will revolve until the stress of the untwisting strands just equals the resistance of the threads being twisted tighter. In making a rope it is impossible to always make these strains exactly balance each other when the rope is sent out to go into service. It is this fact that makes it necessary to take out the "turns" in a new rope, that is, untwist it when it is put at work. The proper relative twist that should be put in the threads and in the strands has been ascertained approximately by long experience. There is, however, a difference in judgment among different foremen as to the exact amount that should be used for any specific work. The greater the twist the harder and more rigid is the rope, and the better it will keep its form, but it is not quite as strong, because the fibers under maximum stress do not lie exactly in the direction of the center line of

* Copyright, 1912, by C. W. Hunt Company, New York.

Fig. 4.—Rope Drive Between Buildings, Equipped With 3,000 feet of Rope in One Length. Distance Between Centers of Sheaves, 165 feet.

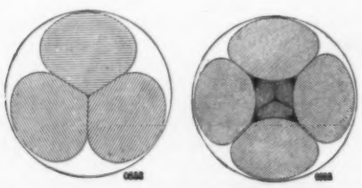


Fig. 5.—Cross Sections of Three-strand and Four-strand Rope.

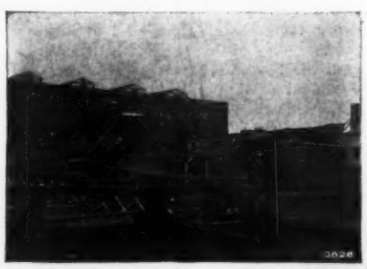


Fig. 6.—Continuous System of Rope Drives in a Packing House, Showing an Extensive System of Outdoor Drives.

Fig. 7.—Spools of Yarn Ready to Make Into Rope. Each Yarn is 1,200 Feet Long.

Fig. 8.—Opening Bales of Manila Fiber.

the rope, but at an angle with it, and the greater the twist the greater is that angle.

Durability.—The amount of work that the rope will do varies greatly in different applications. It depends not only on the quality of the fiber and the method of laying up the rope, but also on the kind of weather when the rope is used, the diameter and material of blocks or sheaves over which it is run, and the stress put upon the rope. The principal source of destructive wear in practice arises from an excessive load, or from defective or unsuitable sheaves.

For the most economical wear the loads put upon the rope should not exceed those given in Table I. The indications of excessive load will be unusual stretch, the twist apparently coming out of the rope; or one of the strands slipping out of its proper position. A certain amount of twist in a hoisting rope comes out in using it the first day or two, but after that the rope should remain for a long time substantially the same. If it does not, the load is too great for the durability of the rope. If the rope wears on the outside, and is good on the inside, it shows that it has been chafed in running over the pulleys or sheaves. If the blocks are very small it will increase the sliding on each other of the strands and threads before spoken of, and result in a more rapid internal wear.

Strand.—Experience has shown that four-strand rope is more serviceable than three-strand. It is stronger for the same diameter than a three-strand rope, and wears rounder and smoother. An examination of the cross section of the rope of four strands and the one of three strands will show that the section of a four-strand rope is much nearer a circle, and also that the area of the strands in contact with each other to bear the pressure, is much greater.

Strength and Weight.—The strength and weight of manila rope based on tests made by the author are as follows:

7160 × (diameter, inches)² = Breaking strength in pounds.

0.34 × (diameter, inches)² = Weight per lineal foot in pounds..

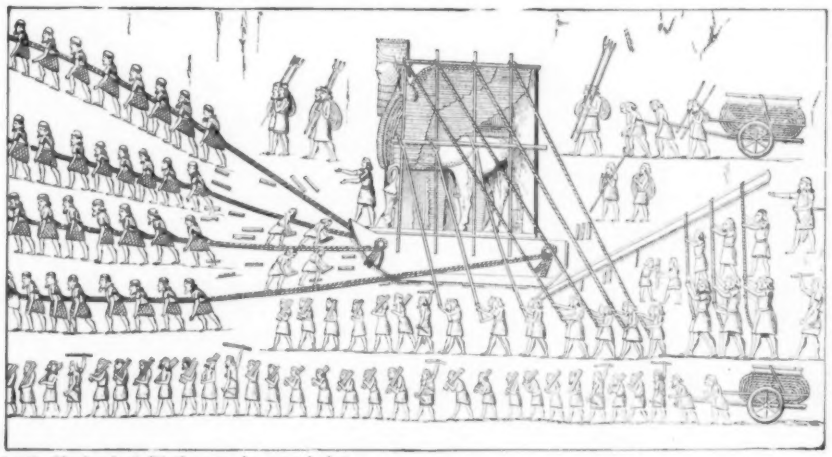
It is interesting to note that pound for pound, manila rope is as strong as steel. A bar of rolled steel 1 inch square and 1 foot long will weigh 3.33 pounds and will have a breaking strength of 64,000 pounds. A manila rope 1 inch in diameter will weigh 0.34 pounds per lineal foot and will have a breaking strength of 7,160 pounds. From this we deduce the strength of a rope equal to the weight of a bar of steel 1 inch square, to be $(7{,}100 \times 3.33) \div 0.34 = 69{,}000$ pounds.

Leather Belts.—A comparison of leather belts and manila rope for transmitting power may be made by comparing the power transmitted by ropes given in Table II with the proportions for double leather belting given in an article by F. W. Taylor (A.S.M.E. Volume XV-204). The comparison shows that a manila rope 1 inch diameter is equal in driving power to a double leather belt 2⅝ inches wide, each running at the same speed.

Advantages.—The use of rope for the transmission of power is but one of several methods of accomplishing the same object. The advantages that are found in this method of transmission of power are:

1. Transmitting large amounts of power.
2. Runs in any direction.
3. Smooth and quiet running.
4. Absence of electrical disturbances.
5. Economy in first cost.
6. Economy in maintenance.
7. The accurate alignment of sheaves is rendered unnecessary.

The transmission of power in mill work may be accomplished by gearing, by shafting, by electric motors, by leather or rope belting. Which one of these should be used in a particular case is a problem for the engineer in charge to determine. A special advantage in rope driving is the satisfactory service of the ropes when the shafts are not exactly parallel. Without altering the form of the groove in the pulley, ropes run very well with the shafts at an angle to each other of two degrees, and have been used with satisfaction up to three degrees. When the angle is greater the form of the grooves should be altered.



From Knight's Mechanical Dictionary, by permission.

Fig. 9.—Assyrians Moving a Human-headed bull. Copied from a Bas-relief at Koyunjik. This Sculpture is of the Age of Osirtasen II., the Contemporary of Joseph. Between 1652 and 1636 B. C.

Systems.—There are in use three modes of mounting ropes on the pulleys, each having advantages so that in any particular case the selection calls for a careful consideration of the situation and its governing factors.

1. Band System. Each rope is spliced endless and runs in grooves of its own. As many bands are used as are needed to transmit the required power.

2. Tension Pulley System. The rope is wrapped around the driving and driven pulleys as many times as may be necessary to transmit the power and a loop carried over a tension pulley. This pulley has a tension weight that moves it back and forth, thus keeping a definite and constant tension on the ropes.

3. Coupling System. This is the same as the "Band" System, except that the ropes are made with a detachable coupling instead of a splice, thus permitting the rope to be shortened as it stretches by putting more twist into it.

Bands.—The advantages of the Band System are:

Any number of ropes can be placed side by side, each rope taking its proportion of the load.

Low cost of installation.

Low cost of spare parts.

Maximum length of life of rope.

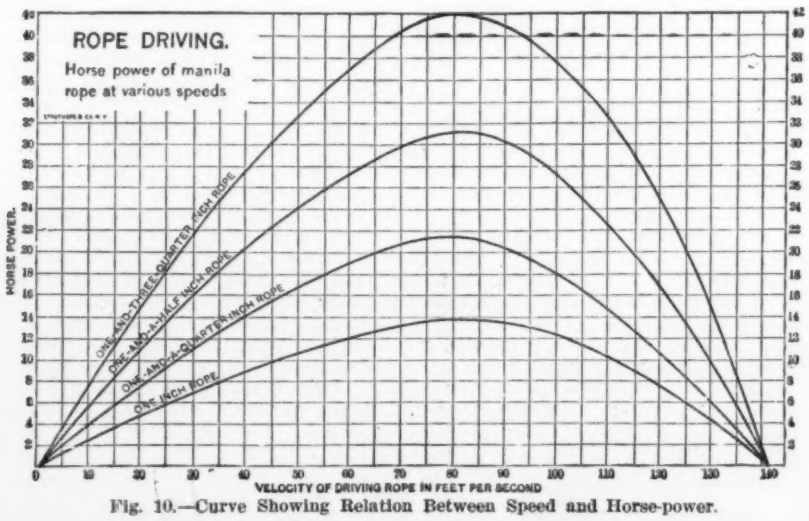

ROPE DRIVING.
Horse power of manila rope at various speeds
HORSE POWER.
ONE-AND-THREE-QUARTER INCH ROPE
ONE-AND-A-HALF INCH ROPE
ONE-AND-ONE-QUARTER INCH ROPE
ONE INCH ROPE
VELOCITY OF DRIVING ROPE IN FEET PER SECOND

Fig. 10.—Curve Showing Relation Between Speed and Horse-power.

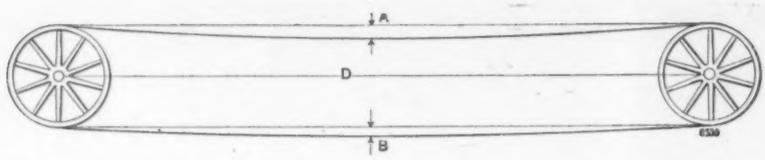


Fig. 10.—Simple Arrangement. There are Only Two Bends, Both in the Same Direction.

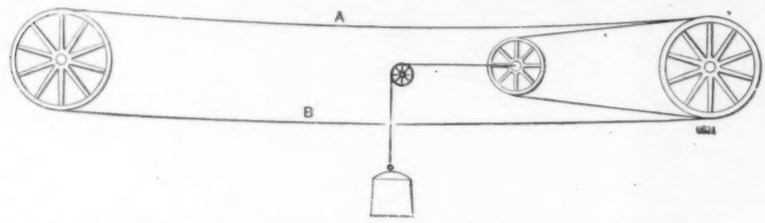


Fig. 11.—Arrangement with Tensioning Weight. All Bends are in the Same Direction.

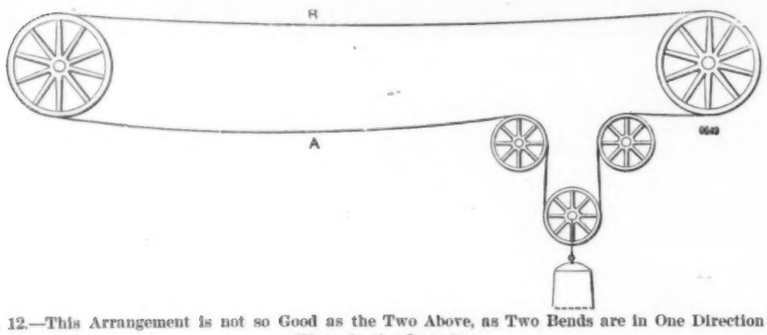


Fig. 12.—This Arrangement is not so Good as the Two Above, as Two Bends are in One Direction and Three in the Opposite.

Couplings.—The good points of the Coupling System are:

The tension of the ropes can be kept constant.

A new rope can be put on in a few minutes.

Freedom from interruption to the plant to renew bands.

Pulleys, if necessary, can be close together.

Tension Pulleys.—The advantages of the Tension System are:

The tension on the ropes can be accurately adjusted.

There is but one splice in the rope.

The tension is constant during the life of the rope.

Comparison of Systems.—It will be noted from the advantages of the several systems as set forth above that the coupling and tension pulley systems are similar, in that the tension on the ropes with both is constantly maintained. Furthermore, in the coupling system each rope is connected independently and the general advantages of the band system may therefore be considered as also applying.

In the selection of a system the large field of usefulness of the tension pulley system must not be forgotten. While it is generally considered better, where possible, to use a number of ropes connected independently rather than one continuous rope, the tension weight in this system allows of quick adjustment of the rope such as would be necessary when a rope shortens and lengthens from shrinkage or stretch under changing atmospheric conditions. In this system, however, the protracted interruption of business to install a new rope must be considered, also the greater cost of spare rope, compared to the cost of necessary spare rope in the other two systems.

The three systems of rope driving will cover a great variety of driving conditions and a careful selection of the system to be used will result in a highly efficient transmission.

Stiffness.—The rigidity of either rope or belting used in transmitting power has not been ascertained by conclusive experiments, but such as have been made show that there is but slight difference between the ordinary manila rope and leather belting. Ropes made specially for the transmission of power, show by the experiments of Robert Grimshaw a marked reduction in the friction loss. When we consider that a rope two inches in diameter and a double leather belt ten inches wide are equal in driving capacity, we can well doubt if the loss from creeping and stiffness in transmission rope is as much as one half the loss with equivalent belting.

For successful work the pulleys must be large in diameter, and have a smooth surface where the rope bears upon them. The speed and the load on the rope must also be such as experience has shown to be economical. When these conditions are fulfilled, a rope drive is one of the most satisfactory methods of transmitting power.

Reverse Bends.—Much depends also upon the arrangement of the rope on the pulleys, especially where a tension weight is used. Experience shows that the increased wear on the rope from bending, first in one direction and then in the other, is similar to that of wire rope. At mines where two cages of equal weight are used, one being hoisted and one lowered by the same engine, the ropes doing the same work are usually arranged so that one rope is bent continuously in one direction, and the other rope is bent first in one direction and then in the other in winding on the drum of the engine.

The rope having the opposite bends wears much more rapidly than the other, lasting about three quarters as long as its mate. A similar difference in wear shows in manila rope when reverse bends are used, both in tranmission of power and in coal hoisting. The pulleys should be arranged, whenever it is possible, to bend the rope in one direction.

Fig. 10 shows the rope arranged in the most favorable manner, bending on a pulley only twice in a round trip, with both bends in the same direction. The arrangements in Fig. 11 is not as good, as the rope is bent four times instead of twice, and, in addition one of the bends is over a small pulley, which causes more wear to the rope than when bending on a large one. The arrangement shown in Fig. 12 is still more unfavorable, having five bends to the rope, three of these bends being over small pulleys, and four of the five are reverse bends. It cannot be expected that ropes arranged in this manner will give anything like the service that the arrangement shown in Fig. 10 will.

Pulley Diameter.—The diameter of the pulleys has an important effect on the wear of the rope—the larger the sheaves the less the fibers of the rope slide on each other, and consequently there is less internal wear of the rope. For economical wear the pulleys should not be less than forty times the diameter of the rope, and as much larger as it is practicable to make them. This rule applies to the idle and tension pulleys as well as to the main driving pulley. It will be noticed that the wear of the rope takes place only on the sheaves, by the sliding of the fibers on each other in bending the rope and by the friction against the sides of the grooves of the pulleys; hence the life of a rope is increased as the distance between the sheaves is increased, because each point of the rope touches the sheaves less frequently.

Tension Pulleys.—Contrary to the usual practice, I recommend that the tension, idle, and supporting pulleys shall have the same form of groove as the driving pulleys, and the pulley as light in weight as possible, in order that the momentary fluctuations of speed of the rope may carry the pulley with it, instead of slipping the rope on the bottom of the groove by the inertia of the pulley.

Pulley Groove.—The groove of the pulley in which the rope runs should be made with the greatest care as to its diameter, its form, and its workmanship. If the angle of the groove is too sharp the rope wedges down and puts an unnecessary pressure and friction upon it; while, if the rope receives a swaying motion from the wind or any other cause, it chafes against the sides causing excessive wear. A groove having an angle of 45 degrees has proved to be perfectly satisfactory in practice. This angle is equivalent to increasing the coefficient of friction of the rope on a flat face pulley over two and a half times. The sides of the grooves are straight and the bottom flat, the object being to have a groove which will have the same coefficient friction when the rope is new and when it has worn smaller in diameter. Another advantage of this groove is that it is a definite one that can be easily measured and accurately made by a workman.

Polished Grooves.—It is very important that the sides of these grooves should not only be accurately turned, but carefully polished, as the fibers of the rope rubbing on the metal left as it comes from the lathe tools, will injure the rope, breaking fiber by fiber, and so give the rope a short life. If the sides of the grooves were polished as smoothly as the sides of a razor, the life of the rope would be indefinitely prolonged, as the wear of rope is principally caused by rubbing on the grooves of the pulley and not by the internal chafing of the fibers of the plumbago-lubricated rope, such as occurs with the ordinary manila ropes. It is also necessary to carefully avoid all sand or blow holes, as they will cut out the rope with surprising rapidity.

Creep.—The stress on the driving part elongates the rope and thus makes the stretched part correspondingly smaller in diameter than the returning part of the rope. The tension is gradually decreasing as it passes from the entering to the delivery side of the driver, thus causing a slow creep of the rope on the pulley. As it creeps the rope also changes its depth in the groove; so that when it leaves the groove to return to the driven pulley it is in the groove only to the depth that its tension at that point requires it to be. The effect on the driven pulley is similar but in a reverse order. In either case the rope is pressed into the groove at all points in the circumference of the pulley only in proportion to the tension on the driving and return parts of the rope.

Horse-power.—We give herewith a table of the horse-power of driving ropes and the diameter of pulleys that should be used in the practical installation of a rope drive. The basis for this table is the assumption that a rope one inch in diameter should have a working stress of 200 pounds at all speeds. This is about one twentieth of the strength of the splice. This large margin is to enable the rope to perform a large amount of useful work before it is so weakened by wear that it requires to be renewed, and also to take care of the many strains which cannot be computed owing to the irregularities of the power and the work.

Centrifugal Force.—The centrifugal force of a rope in bending around a rapidly revolving pulley becomes a material factor at high speeds. To properly realize this we can imagine an elastic rope belt gradually increasing in speed until the centrifugal force on the pulleys is equal to the full tension that experience shows should not be exceeded. The rope is then running at a high speed, but without transmitting any power to the pulleys, as it is strained up to its full working limit. Gradually decreasing the speed the centrifugal force decreases, permitting the rope to use the remainder of the stress in driving the pulleys. Table II. is computed for various sizes of manila rope, and speeds up to the point when the centrifugal force equals the assumed maximum tension allowable, which, as heretofore stated, is 200 pounds on a rope one inch in diameter. The data in the table are graphically shown in Fig. 10, which clearly illustrates the rapid falling off in the driving power at high speeds. We are aware that some engineers recommend a higher stress for the rope and a greater horse-power than given in Table II., but we believe that this table should be used except in temporary installations.

Air Resistance.—The curves in Fig. .. show that when the stress on the rope alone is considered, the most economical speed for rope driving is about 5,000 feet per minute. The resistance of the air to the motion of the rope and to the pulleys is not taken into consideration in the table, but it is known to be large at high speeds. Data on the subject are not available to accurately determine how much it is in an ordinary commercial drive. A rope two inches in diameter is in strength, equal in driving power to four ropes one inch in diameter, but the surface exposed to the resistance of the air is only one half that of the small ones. The arms and rim of the pulleys also meet with great air resistance at high speeds. The most economical speed is evidently less than that shown in the curve.

Correction.—In deciding upon the rope speed to adopt in a given case, the advantage of a reduced first cost and smaller interest charge must be balanced against

TABLE I.

A. Diameter of Rope, Inches.	B. Ultimate Strength, Pounds.	C Working Load in Pounds. Rapid	D. Medium.	E. Slow	F Minimum Diameter of Sheaves in inches. Rapid	G. Medium.	H. Slow
1	7,100	200	400	1,000	40	12	8
1⅛	9,000	250	500	1,250	45	13	9
1¼	11,000	300	600	1,500	50	14	10
1⅜	13,400	380	750	1,900	55	15	11
1½	15,800	450	900	2,200	60	16	12
1⅝	18,800	580	1,100	2,600	65	17	13
1¾	21,800	620	1,250	3,000	70	18	14

Table I.—Working Load for Manila Rope.

TABLE II.

Diam. of Ropes.	SPEED OF THE ROPE IN FEET PER MINUTE 1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	Smallest Diam. of Pulleys in Inches.
½	1.45	1.9	2.3	2.7	3.	3.2	3.4	3.4	3.1	2.2	0	20
⅝	2.3	3.2	3.6	4.2	4.6	5.0	5.3	5.3	4.9	3.4	0	25
¾	3.3	4.3	5.2	5.8	6.7	7.2	7.7	7.7	7.1	4.9	0	30
⅞	4.5	5.9	7.0	8.2	9.1	9.8	10.8	10.7	9.3	6.9	0	36
1	5.8	7.7	9.2	10.7	11.9	12.8	13.6	13.7	12.5	8.8	0	42
1¼	9.2	12.1	14.3	16.8	18.6	20.0	21.2	21.4	19.5	13.8	0	54
1½	13.1	17.4	20.7	23.1	26.8	28.8	30.6	30.8	28.2	19.8	0	60
1¾	18.	23.7	28.2	32.8	36.4	39.2	41.5	41.8	37.4	27.6	0	72
2	23.1	30.8	36.8	42.8	47.6	51.2	54.4	54.8	50.	35.2	0	84

Table II.—Horse-power of Manila Rope at Various Speeds, With an Arc of Contact of 180 Degrees.*

the loss in the daily operation from wasted energy in the air resistance of the rope and the pulleys at high speeds. The engineer in charge must make a study of the conditions and decide each case on its own merits. In unimportant drives, the error will not be great if for high speeds, we say empirically that the driving power of three quarters of that given in the Table II is a reasonable assumption. With a given velocity of the driving rope, the weight of rope required for transmitting a given horse-power is the same, no matter what size rope is adopted. The smaller rope will require more parts, but the gross weight will be the same.

Lubrication.—Under normal conditions a transmission rope made up with a lubricant applied to the threads before they are laid up into strands, requires none applied to it in service. If the rope runs in a hot or dry place, or outdoors exposed to the weather, it will be benefited by applying a dressing to it while in motion. The dressing selected should be of the same lubricant as that used in making up the rope. If the rope is laid up in a plumbago and tallow lubricant, a similar preparation should be applied as a dressing. The exterior may be coated lightly, softening the fibers if too dry and making it waterproof if exposed to the weather.

* In this table the total stress on the driving side of the rope is the same at all speeds, due allowance having been made for the reduction in driving power due to the centrifugal force of the rope on the pulleys.

False Food Standards and the High Cost of Living*

The Cheaper Cuts as Nutritive as the More Costly

THE current discussion regarding the high cost of living raises the question as to the various ways in which the situation can be met and ameliorated. Legislative enactments can accomplish no permanent gain when they are based on false principles; for economic adjustments are bound to follow in counteracting ways along directions that are often totally unsuspected. Propaganda is likewise rarely productive of helpful and permanent reforms unless it relies on indisputable scientific facts and makes a rational appeal to the masses. On the other hand, there are popular prejudices so deeply rooted that it frequently seems almost hopeless to attempt to correct them, especially in these days when almost every legitimate effort at scientific reform is popularly charged with elements of suspicion.

It is easy enough to secure attention for some new food product by a well-worded advertisement, or to win favor for some ridiculous impossibility such as soap made from buttermilk or oatmeal; but pages of argument are unavailing to convince the average American that real butter is rarely of a deep yellow color. Too often the pure product awakens in him the suggestion of grease, so thoroughly has he become falsely trained to demand artificial color in butter.

Meats are among the most expensive factors in the dietary of man, making up about one third of the average expenditure for food; and the butcher shop is the center around which many mistaken notions revolve. Certain "cuts" of meat are regarded as exceptionally choice and are much in demand, leaving a large portion of the carcass far less desired. This situation has at length reached the point where the loins and ribs forming only about one fourth of the weight of the salable parts represent nearly one half of the retail cost.[1] We may well ask whether such discrepancies in cost are justifiable on any rational grounds other than those of prejudice.

It must be frankly admitted that few purchasers and fewer consumers of meat have any accurate basis for a sound judgment in buying cuts of meat. Palatability of course plays a prominent part in the selections made; but there is an added undercurrent of belief that the more expensive cuts are somehow more wholesome and "strengthening." Now nutritive value, in the case of meats, is essentially determined by their content of protein and fats. There is a wide difference between different cuts in respect to the fact content; but since the latter can advantageously be supplied in other relatively inexpensive ways, the chief emphasis must be laid on the protein value of meats. A comparison of the cost of one pound of protein (not of meat) furnished by different parts of the carcass has been made from data compiled at the University of Illinois. These show clearly that the cheaper cuts of beef are by far the most economical sources of both lean and total edible meat, including fat and lean. Some actual figures are highly elucidating. The cheaper cuts, such as the neck, shank and clod, furnish protein for from 46 to 63 cents per pound; the flank, plate and chuck cuts, for about 85 cents; the loin, for $1.88. In terms of calorie cost the facts are equally striking, the wholesale price of 1,000 calories varying from 5 cents for the flank, plate and neck, to 15 cents for the loin and round.

Certain obvious criticisms of such a comparison may be answered at once. It must be freely admitted that some of the cheaper cuts are less tender and therefore more difficult to prepare for use than choice steaks and roasts. This is, however, in no small degree a problem which ought to be solved by expert culinary skill, just as it has been in the wholesale production of ready-to-eat cereals. There is little difference between the various cuts as to their content of those components, namely the extractives, which lend flavor and palatability to cooked meat. Cooking tests indicate that the proportion of waste and shrinkage is not necessarily greater in the cheaper than in the more expensive cuts. Furthermore, there is satisfactory evidence[2] that the digestibility is to a large extent independent of the kind or cut of meat and of the method of cooking.

The facts cited indicate how the retail prices of beef cuts are determined chiefly by considerations other than their food value, notably by tenderness, color, grain, general appearance and convenience in cooking. It is high time that those purchasers to whom matters of justifiable economy make an appeal should be educated to appreciate the irrational standards that characterize the demand for beef, to realize that the low-priced cuts are by far the most economical sources of nutriment from flesh, and accordingly to profit by the prevailing discrepancies in market prices. This advice applies in equal measure to public institutions, including hospitals, where a misapplied sense of duty often leads to well-meant but ill-judged dietary extravagance.

* Reproduced from the *Journal of the American Medical Association.*

[1] These and other details are taken from Hall, L.D., and Emmett, A.D.: Relative Economy, Composition and Nutritive Value of the Various Cuts of Beef, Univ. of Illinois Agr. Expt. Sta., Bull. 158, July, 1912.

[2] Compare Grindley and Emmett: Office of Experiment Stations, Bull. 162, 1903. Grindley, Mojonnier and Porter: ibid., Bull. 193, 1907.

The Removal of Ink from Waste Paper*

PATENTS almost without number have been taken out in connection with this subject, the removal of ink, particularly printers' ink, from waste paper. No process, however, has yet been found economical in regard to cost and satisfactory in respect of the results.

The treatment of papers printed chiefly with soluble inks and dyes does not offer much difficulty, as such coloring matters, being soluble in water or any stronger chemicals, such as acid and alkali, are rendered colorless. In many cases the mere soaking in water is sufficient to remove the ink and to give a pulp of a fairly white character.

The treatment of paper containing ordinary printers' ink has not been attended with success, and this is not surprising when we consider the nature and composition of the printing ink itself. It may be said that most inks consist of some pigment combined with an oil or varnish body known as a vehicle.

The treatment of waste papers of the first class does not offer very great difficulties, but the ink used for newspapers is of a totally different character. The pigment is usually some form of lampblack or carbon black mixed with resin varnish prepared by the distillation of resin, and also heavy mineral oils which are of a cheaper and commoner quality and suitable as a vehicle. The more expensive boiled vegetable oils, such as linseed, are only used in the very best qualities of ink.

The many patents which have been taken out in the hope of removing ink of such a character from waste newspapers have been based mainly on the use of some form of alkali, either in the shape of carbonate of soda, or caustic soda, and other modifications of these alkalies of a less caustic property in the form of soaps.

With varnishes from vegetable oil which saponify fairly readily on treatment with alkali which dissolves the oily constituents of the ink and forms a soluble soap, the printing ink to some extent is detached from the surface of the paper, and if it were possible to treat the paper superficially and carry away the dissolved and the loosened constituents, there might be some chance of more or less complete removal of the ink. But the pigment constituents of the ink, namely, the minute particles of carbon, are not in any sense attacked, being merely freed from their combination with the varnish, and any attempts to remove this pigment constituent are based entirely on removal by mechanical means. In other words, every process so far suggested has been based on systems which necessitate the dissolving of the oily vehicle, and agitation of the mass subsequently in order to get rid of the fine particles of carbon by mechanical separation. This is easily effected by some form of sieve, such as an ordinary drum washer revolving in the vessel containing the old waste paper suitably pulped, or by passing the pulped newspaper treated with the alkali or soap over flat sieves.

There are two defects in any process based on this system of washing; the first being a serious loss of weight owing to the removal of a very large proportion of the china clay and small fibrous matter from the original paper; and, secondly, the impossibility of taking out the whole of the carbon. The final result is merely a pulp of grayish color, somewhat stronger than the original newspaper, but with its weight seriously diminished, so that the cost of treatment based on the final yield of air-dry pulp obtained is much higher than is warranted by the color and quality of the product obtained.

It need hardly be pointed out that the introduction of mineral oils which are not easily saponified by alkali has rendered the case still more hopeless, since the oily constituents of the ink are not made soluble by the addition of alkali, and the reduction of the paper to pulp for the purpose of washing does not effect any material change in color.

A patent has recently been taken out for the use of borax, and it is claimed that this material does not produce a discoloration of the fibers of the mechanical wood pulp similar to the yellowish tone imparted by ordinary caustic alkalies. In this process the waste newspapers are boiled in a solution containing about 2 pounds of borax in 1,000 pounds of water. The conversion of the oily vehicle into a soluble form is generally easily accomplished by any such process, but the removal of the pigment itself has so far defied all attempts.

* *Paper Makers' Monthly Journal.*

The Midnight Visitor.

Freak Gymnastics.

Close Quarters.

Methods of Freak Photography

How the Camera Can Lie

By Percy Collins

A KNOWLEDGE of the various methods by which photographs may be produced is of no small value to the amateur and professional worker. The well-nigh insatiable demand which exists for curious and interesting pictures makes it necessary for the latter to be up-to-date and original in his output; while the former is always desirous of surprising his circle of acquaintances by some new evidence of his skill. By following the hints contained in this article the reader will be able to produce an almost endless number of strange and deceptive pictures, not a few of which will be provocative of mirth.

Moonlight effects in photography are generally gained by trickery. Of course, it is possible to take photographs by moonlight, the exposure varying from thirty minutes to two hours; the results, however, are rarely satisfactory, owing to the movement of the shadows producing a blurred effect in the finished print. To obtain a moonlight picture of the approved sort—a fine cloud effect with the moon casting a long line of brilliant light upon water—special preparations must be made. A rather cloudy sunset must be chosen. Then, when the sun drops low on the horizon, and is partially obscured by the cloud bank, one seizes the opportunity to secure a snapshot (the lens being well "stopped down") right into the eye of the light. The plate thus obtained should be slightly under-developed. If all has gone well, the resulting negative will supply a picture exactly resembling a moonlight effect; and by carefully gumming a small circle of opaque paper upon the film, one is able to print out the "moon" into the bargain. Such negatives are most effective when transferred to green albuminized paper; and the printing should be decidedly deeper than in the case of an ordinary negative.

Photographs in which the snow appears to be falling are usually produced by artificial means. If the subject is to be a portrait, the sitter should be garbed appropriately, and placed before a wintry background When the negative is obtained, it should be dried and well varnished, then place it flat upon a table with the film side uppermost. Take a soft toothbrush charged with rather thick Indian ink and carmine mixed up with water, and draw it over the teeth of a comb, which should be held some little distance from the negative. If this operation is carefully managed, the result will be an irregular spattering of the pigment upon the varnished film; and when this is dry, a print will be produced which looks just as though the negative had been taken in a snowstorm.

Photographs of the class in which ghosts or visions appear may be "faked" in several ways. The first of these may be described as the duplicate exposure method. Suppose, for example, we wish to photograph a man inside a bottle which will hold no more than a pint of liquid. To accomplish this apparently impossible feat proceed as follows: First photograph the bottle standing upon a dull black support and with similar background. While focussing, take care to mark out what will be the bottle's boundaries on the plate by fixing little pieces of gummed paper to the ground glass screen of the camera. Then get your man to stand or sit in a chair upon a black cloth, with a smooth black curtain behind him. Focus upon him so that he falls within the boundaries of the bottle—this being easily managed by means of the gummed paper guides. Finally, expose the plate which has already been used to photograph the bottle; and when this is developed your friend will duly appear—inside!

This method will be found in practice to explain many pictures which at first seem very astonishing. To make a "vision fake," arrange a little scene, such as a bare room with an empty hearth, with your model sitting listlessly in the foreground. Make your first exposure on this scene, being careful to mark out on the ground glass screen the space into which the vision must fall. A dark curtain, or dark woodwork, should occupy this space in the first picture. Now procure a sheet of dead black paper, mount it evenly upon stiff card, and with a little Chinese white sketch out an appropriate vision. If you cannot do this yourself, get an artist friend to help you; but see that the sketch is placed in the correct spot, i. e., the spot which you have arranged for it to occupy in the finished picture. When the sketch is finished, set it up before the camera, focus, and see that it falls within the required boundary upon the screen. Then expose again the plate which has already done duty, and—if no miscalculations have been made—an interesting "vision" picture will result similar to that which is here reproduced.

The ghost "fake" may be made in exactly the same way, only in this case an appropriate scene would be a deserted churchyard, with your model posing in an awestruck attitude beside a tomb. In all photographs of this kind the reader should bear in mind that a dead black background does not appreciably affect the sensitized plate, but a show plate should be used whenever this is possible, as by this means any slight tendency to "fog" will be obviated.

On the whole, however, ghosts and vision photographs are best and most realistic when made in the following way. Get your model to sit or stand in a particular place for about a second while you are exposing; then cap the lens, and let the model walk away from before the camera. Now expose again for two or three seconds more; and on developing the negative there will appear a faint image of the model with the objects behind seen through his or her body. If you drape a white sheet over your model's head and shoulders, the effect will be all the more ghostlike; while you may make your ghost appear to be addressing a warning to someone sitting at a table, or otherwise engaged. While dealing with this subject it may be useful to add that a little sulphate of quinine, say about a quarter of an ounce, dissolved in a pint of water to which a little sulphuric acid has been added, provides a paint which, while invisible to the eye, effects a photographic plate. Thus, any figure or words may be painted upon a dark background and allowed to dry. The marks will be invisible, yet they will appear quite distinct on a negative, and be a source of no small wonder to those who are not in the secret.

Such photographs as seem to show a lady face to face with herself, or playing a game of cards with herself, are very astonishing at first glance. Yet they are very easy to produce. Just inside the camera, as close as possible to the grooves into which the dark slide is placed, should be fitted a thin metal plate, duly blackened to prevent halation. This metal plate should exactly cover one half of the plate when the latter is exposed. The model must now be posed well to one side of the picture, so that her body is seen on one half of the focussing screen which is uncovered by the metal plate. After focussing, the plate holder should be inserted and the exposure made in the ordinary way. Then, after removing the dark slide, the metal plate should be moved so that it covers the other half of the plate, and the sitter also move over to the other side of the picture. A little thought and ingenuity will enable the photographer to pose his model and "stage" his picture effectively. On developing such a negative, the same person will be shown in two positions; and if the metal plate has been carefully made and blackened, there will be absolutely no trace of a join. By having several metal plates instead of one, and moving them about as required, the model may be made to appear three or four times upon the same negative.

Another way of obtaining this particular kind of freak photograph is to fit a tube in front of the lens. Instead of using a cap, the tube should be closed with a kind of folding door arrangement, so that one half of the lens may be uncovered at a time. A still more simple plan is to use a cap which covers only one half the aperture, and to control the exposure by means of a shutter behind the lens. This method, however, makes it necessary to "stop down" the lens to at least f/3, and a long exposure is thus rendered inevitable.

It is well known that the nearer an object is to the

camera the larger it appears to be in proportion to other objects in the picture; and by taking advantage of this fact some astonishing pictures may be obtained, particularly if a lens of somewhat short focus be employed. Not long ago, the writer saw reproduced in a popular magazine a photograph which was described in all seriousness as depicting a cabbage of gigantic proportions. Doubtless, most people who looked at the picture were deceived, for the cabbage partially obscured a whole family of five or six persons who stood somewhat in the background. Yet in reality, the vegetable was of only ordinary proportions, and merely *looked large* in proportion to the human beings because of its nearness to a lens of short focus. In the same way, if a fisherman has caught a fish six inches long, it may be made to appear gigantic in the photograph. By means of his rod and line the fisherman may hang his fish a good six or eight feet nearer the camera than he himself is, and the lens does the rest.

Very laughable caricature photographs may be made by simply moving the "swing back" of the camera out of the perpendicular. Your friends may be made to look like reclining giants, or dwarfs with big heads. In fact, an almost endless variety of quaint deformities may be devised by varying the elevation of the camera and the angle of the back. Care must be taken, however, to "stop down" the lens as much as possible, in order to bring the whole picture well into focus. This, of course, means that a good light is required, otherwise the exposure must be a long one, and your model may move and spoil the picture. Another method is to discard altogether the ordinary lens of the camera and make use of two metal plates, placed one behind the other in the lens tube, each provided with very narrow slits about 1/50 inch wide and 1/2 inch long. By training these slits at different angles, all sorts of curious effects can be obtained. In this case also a very long exposure is necessary; but this may be avoided by first taking the negative in the ordinary way, then making a transparency from it by contact printing, and finally copying this in the camera by means of the slits.

Many marvelous effects may be gained by the simple process of erecting a scaffolding, and focussing the camera so that its lens (which should be of wide angle) occupies a vertical position. A photograph taken in this way is here reproduced. Some pieces of wall paper were spread upon the ground, and upon them the gentleman reclined, not uncomfortably, upon his back, with his head touching the seat of the overturned chair. The picture was added to enhance the effect, and the resulting photograph seems to portray a quite impossible gymnastic feat.

Vegetable Ivory of Commerce

VEGETABLE ivory (Marfil vegetal) of commerce is the fruit of the antá (*Phytelephas macrocarpa*), which is said to be the most beautiful palm in the world when it is in bloom. Its range of growth is confined to Panama and to the northern part of South America.

The matured fruit consists of a collection of six or seven drupes, forming clusters which are as large as a man's head, the drupes being covered with hard woody protuberances. In Colombia these drupes are called *cabeza de negra*, or negro's head. Each drupe contains from six to nine seeds, which are formed in the interior, and at first consist of a clear insipid substance, which soon becomes a milky-white sweet liquid. This albuminous matter gradually hardens until it is as refractory as ivory. The seeds are then collected by the natives and shipped in large quantities to Europe and to the United States, where they form the chief substitute for elephant ivory, and are used very extensively for making small articles of turnery, such as buttons, toys, knobs, and reels.

The export of these nuts from Panama, Colombia and Ecuador is constantly increasing, and at enhanced prices; the shipments to the United States in 1901 amounted to 13,461,461 pounds, which increased to 27,066,716 pounds in 1910. They are imported into England to an amount of two to three times as great as true ivory. A most notable increase in the shipment of vegetable ivory from tropical America to the United States was observed immediately after the approval of the new United States tariff on July 24th, 1897. Previous to that time the bulk of the vegetable ivory was shipped to Hamburg, Germany, where it was utilized in the great button manufactories, and shipments to the United States were proportionally small. The new custom tariff which imposed a specific and *ad valorem* duty on buttons made of vegetable ivory, created an immediate change in the market for the raw material. This duty naturally limited the importation of buttons from Germany into the United States, and led merchants to expect a speedy and large increase in the manufacture of buttons in this country, which explains the increase in the importation of nuts.

According to statistics compiled by the Treasury Department at Washington, the quantities and values of vegetable ivory imported into this country from 1901 to 1910, inclusive, were as follows:

Year.	Pounds.	Value.
1901	13,461,461	$179,735
1902	14,699,215	165,489
1903	17,194,434	192,093
1904	15,740,792	229,944
1905	19,688,913	410,883
1906	21,076,508	516,607
1907	16,602,229	464,931
1908	14,536,288	375,535
1909	20,002,909	609,062
1910	27,066,716	1,104,924

No serious attempts have as yet been made to introduce this valuable palm into any of the tropical countries of the western hemisphere despite the promise of profit. In Jamaica, Trinidad and Dominica the ivory palm would doubtless thrive. Several new species have recently been found which grow in Colombia and Ecuador, and these have been introduced into the botanical garden of Victoria in Kamerun in West Africa for the purpose of testing them for commercial planting. Practically all the seeds germinated, and the plants give promise of success in this new industry.

It is said that the Ecuadorian varieties produce by far the most desirable nuts.

"A Vision" Produced by Double Exposure.

Heads I Win, Tails You Lose. A "Double Exposure" Freak.

An Apparition in the Churchyard.

Second Exposure in the Apparition Scene.

The Synthesis of Ammonia from Its Elements—II*

The Commercial Exploitation of the Earth's Atmosphere

By Prof. H. A. Bernthsen

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1929, page 387, December 21, 1912

To sum up all these investigations on the direct combination of nitrogen and ammonia, it can be said that the problem seemed now to have become more than ever a mere dream, of which the realization appeared to be quite beyond the bounds of possibility, so that there was every reason why the scientist should turn his back on so unfruitful a field.

In spite of this, Haber had a feeling that a technical synthesis of ammonia from its elements could be rendered possible, and placed himself in communication with the Badische Anilin- & Soda-Fabrik for the promotion of the work. He then showed, still in 1908,[11] that the technical preparation of ammonia from its elements can in fact be carried out, in spite of the unfavorable equilibrium and the low catalytic capacity of the contact metals used, if the mixture of nitrogen and hydrogen is kept under constant pressure during the whole of the operation and is subjected alternately to the catalytic formation of ammonia at a high temperature and then freed from ammonia by absorption or condensation at a lower temperature. Care must at the same time be taken that the heat of the reaction gases containing ammonia is transferred afresh to the gas mixture about to be acted on. In other words, the nitrogen-hydrogen mixture circulates under continuous pressure, through the vessel for the formation of the ammonia, the vessel for the separation of the ammonia and a circulating pump, all these being connected up to a closed endless circuit. Of course it is advisable at the same time to replace with a fresh nitrogen-hydrogen mixture as much of the gas as is converted into ammonia.

It was further found when working according to this continuous process of Haber's under conditions which induce a relatively high concentration of ammonia that the advantages of the heat regeneration are no longer of such vital importance, but that it is sufficient in this case to work continuously under pressure without at the same time regenerating heat.[12] Finally, it was seen[13] that it is not even absolutely necessary to work continuously under pressure (that is, to circulate the gases continuously under pressure), if the reaction is carried out under very high pressure, for instance at about 100 atmospheres, preferably however at from 150 to 250 atmospheres and even higher. A range of pressure is hereby introduced which had never been touched in the synthesis of ammonia and was also something quite new in any manufacture, for no one had previously so much as thought of carrying out technically a catalytic reaction with gas currents at the necessary high temperatures under such an enormous pressure.

By these means, under a pressure of 200 atmospheres, at a temperature of from 650 to 700 deg. Cent. and using an iron catalyst prepared from the purest iron oxid, occupying a space of 20 cubic centimeters, and with a gas speed of 250 liters per hour (measured at ordinary pressure), it is an easy matter to obtain for example 5 grammes, or per liter of contact space, 250 grammes of ammonia in an hour.

The following further point comes here into consideration. All previous publications had in view exclusively the determination of the ammonia equilibrium, which can be found theoretically most accurately in a steady volume of gas. If a current of gas is used, the rate of flow must naturally be kept low, so that one may be sure that equilibrium is reached. Now, there were no indications as to how far the concentration of the gas would be reduced when the rate of flow is raised, and whether the concentration would be sufficient when such a rate of flow is taken as must be done when working on a technical scale. Haber has therefore rendered signal service in showing that one can work successfully with such higher rates of flow.

The apparatus used by Haber[14] may be briefly described as follows: The catalyst is in a metal tube which opens in front into a heat regenerator. The gas mixture passes from behind into the metal tube, through the catalyst and then through the heat regenerator into a circulating pump. Leaving this it passes in countercurrent around the outside of the regenerator tubes and the tube containing the catalyst and then enters this in front, repeating this journey again as described. The apparatus can be protected against loss of heat to the air by packing it in isolating material and can be inclosed in an outer shell which can withstand the pressure. The whole of the circulation takes place at high pressure. The catalyst is kept at the suitable temperature by electrically heating from within or by applying heat from the outside. Between the heat regenerator and the circulating pump the gases pass through either an absorber or a condenser for ammonia. By means of a branch tube the nitrogen and hydrogen combined to ammonia can be replaced.

Finally, it was a great step forward when Haber found catalysts with the property of rapidly combining nitrogen and hydrogen to ammonia in sufficient quantity even at much lower temperatures than those previously required. He found this to be especially the case with osmium. This metal has such a very favorable action even at 550 deg. Cent., and below, that under a pressure of 175 atmospheres a gas concentration of 8 volumes per cent of ammonia can be obtained. This was all the more astonishing, as platinum, which is closely related to osmium, has but a very slight catalytic action. For use on a large scale, however, osmium scarcely comes into consideration, for the world's stock according to Haber does not amount to much over 100 kilogrammes and only small quantities (about 1 killogramme) are obtained annually; this quite apart from its high price and very unpleasant properties.

Very soon Haber found in uranium a further very good catalyst; it can be employed in the form of the metal, of an alloy, or nitrid, or carbid. In the form containing carbon or carbid, such as is produced in the electric arc from uranium oxid and carbon, it crumbles in the gas mixture under high pressure to a very fine powder containing nitrogen, which even under 500 deg. Cent. has an excellent catalytic action. No water, however, or impurities which give rise to water must be present in the gases, when uranium is used in this way. From the following table which shows the equilibria obtainable at different temperatures and pressures, can be seen the importance of the temperature at which a catalyst is active for the equilibrium of the ammonia produced.

EQUILIBRIA (N_2: $3H_2$).

Temp. Deg. Cent.	Pressure. 1 Atmosphere. Per Cent.	Pressure. 100 Atmospheres. Per Cent.
800	0.011	1.1
700	0.021	2.1
600	0.048	4.5
500	0.13	10.8
400	0.48	..

Haber published a short report of his work in 1910.[15] To my great regret Prof. Haber has not been able to accept the invitation of the officers of this Congress to report personally here on his researches, owing to being hindered by pressure of work. I have great pleasure in fulfilling his wish and thanking the officers of the Congress to-day for the honorable invitation, and express his regret to this meeting that he is unable to be present.

I now turn to the work of the Badische Anilin- & Soda-Fabrik on the technical development of the process. This work was of course at once taken up in 1908 after the first communications of Prof. Haber, and Dr. Carl Bosch was intrusted with it. In conjunction with his colleagues and with equal energy and experience in the field of chemistry and engineering he has successfully carried out the practical application of the process.

The problems to be solved were quite new and strange and demanded the mastery of very unusual difficulties. Although working with compressed gases under pressure at very low temperatures was already known in the industry, the problem here was the totally different one of constructing apparatus which should be large enough and at the same time able to withstand the high pressure with temperatures not far from a red heat. How well founded were the doubts as to the possibility of a solution of this task can be gathered from the instance of the wrought iron autoclaves commonly used in the color industry. Here, in spite of a very low range of temperature of at most about 280 deg. Cent., only pressures of from 50 to 100 atmospheres at the utmost come into consideration. But above 400 deg. Cent. iron loses its solidity to a very extraordinary degree.

There is further the circumstance that the metals which come into consideration for the construction of the apparatus, and especially iron, are chemically attacked above certain temperatures by the gas mixture under pressure. Although the formation of iron nitrid from iron and ammonia, which could have been expected according to the work of Frémy and others, can be avoided, yet it is found, for example, that steel containing carbon loses its carbon at the temperatures in question owing to the action of the hydrogen, so that its capability of withstanding pressure is reduced to a minimum. It was further found, when using iron itself, that it is completely changed in its qualities, chiefly by taking up hydrogen. Again, at such high temperatures iron is pervious to quite a remarkable degree to hydrogen under high pressures. The question of materials for the apparatus therefore raised at once considerable difficulties, but at length these were more than overcome by suitable construction. The danger of serious explosions or of great sudden flames of hydrogen, if the apparatus happens to become defective, can be guarded against by setting it up in bomb-proof chambers.

Great care must naturally be taken that oxygen or air does not get into the apparatus or the piping, for at the high pressure obtaining the explosion range is reached with merely a slight percentage of oxygen. Special devices are used to watch over this content of oxygen, and immediately a definite percentage is touched the alarm is automatically raised. Besides this the proper constitution of the gas mixture in circulation is controlled by analysis from time to time.

The ammonia can be removed either by being drawn directly from the apparatus in liquid form, or an absorption agent can be suitably introduced into the apparatus. The simplest absorbent, water, has been found to be suited for this purpose; under the pressure used a concentrated solution of ammonia is secured. Any ammonia that may remain in the gas after the bulk has been removed by one or other of these methods can be further removed by special chemical means, if it is not preferred simply to leave it in the circulating gases.

As before mentioned, Haber observed that there are contact agents which are much more active than those previously known (osmium and uranium being indeed found to be much more active than pure iron prepared from oxalate of iron or oxid of iron, platinum, pure manganese, chromium, and nickel, already at considerably lower temperatures). The Badische Anilin- & Soda-Fabrik therefore decided to study the various catalysts very minutely.

In the course of these investigations, the new fact discovered, that ammonia catalysts in general are made more active by the presence of certain foreign bodies, has proved to be of prime importance. Among these "promoters," as they have been termed, are oxids, hydroxids, or salts of the alkalies, of the alkaline earths and the earth metals, further many other substances of the most varied nature, especially other metal compounds or metals themselves. In many cases just a minute quantity suffices to raise the catalytic activity. This trait is common to all catalysts, for there is not one but its activity can be raised by these means. Care must, however, be taken (for reasons to be discussed later on) not to choose such mixtures that metalloids such as sulphur, selenium tellurium, phosphorus, arsenic, boron, etc., under the conditions prevailing, are incorporated in the catalyst. Similarly compounds of metals with a low melting point which are readily reduced by hydrogen and which themselves do not act as catalysts must be avoided; such metals themselves as lead, tin, zinc and bismuth must also not be added.

The promoters mentioned can be added either to the prepared catalyst or to the substances used in its preparation, or the catalyst can be prepared from such materials as already contain such additions in suitable mixture (for example magnetic ironstone). Under certain circumstances the action of these foreign bodies is specially powerful, viz., if the metals, or oxids, or carbonates, or other compounds which are converted into oxids on heating, are first heated to high temperatures, preferably to melting point, and so that the resulting product consists chiefly of oxids. When proceeding in this way with metals, for instance iron, of course sufficient oxygen or oxygen-producing compounds must have access. The mass of oxids obtained as described is suitably broken up and filled into the contact stove either directly or after reduction. In this case extremely small quantities of foreign substances suffice to secure a high and continuous activity of the contact mass.

We consider the marked activity of catalysts prepared in this way to be in the first place due to the fact that

* Paper read before the Eighth International Congress of Applied Chemistry.

[11] German Patent No. 235,421, October 13th, 1908.

[12] French Patent No. 406,943.

[13] German Patent No. 238,450, September 14th, 1909.

[14] See the sketches in Haber's article in the *Zeit. für Elektrochemie*, 16, 244-5 (1910); and also British Patent No. 17,951, 1909.

[15] *Zeit. für Elektrochemie*, 16, 244-5.

the additions mentioned dissolve, on heating, in the highly heated metallic oxid or become finely divided in it, and that in this way during the following reduction a sort of skeleton, which however is hardly to be detected, is formed inside the metallic mass. This effectually prevents a diminution of the surface and therefore also of the catalytic properties of the mass.

It was then further found that good results can also be achieved with pure iron, that is to say, that we can work with it at temperatures of for example not much above 600 deg. Cent., thus if the iron intended for the catalysis is prepared from the oxid or other iron compound at a comparatively low temperature, preferably not above 600 deg. Cent. It can also be prepared by highly heating pure iron oxids, or pure iron in the presence of oxygen, preferably to melting point, and by reducing the mass of oxid preferably at a not too high temperature.

Also manganese, which is related to iron, gives under a specific condition good results, without the addition of foreign substances. This condition is that care be taken to free completely the mixture of nitrogen and hydrogen, before it enters the contact space, from oxygen, either free or combined, for instance as steam or water. Merely drying with calcium chlorid is not sufficient. In the case of several other catalysts too a similar careful drying has proved to be useful.

Again it has been found that another member of the iron group, molybdenum, is by itself an excellent catalyst. Compounds of molybdenum can also be used, for instance molybdic acid or ammonium molybdate.

Under certain conditions, not published as yet, tungsten, either the metal itself or as an alloy or a nitrogen compound, has been found to be a suitable catalyst.[16]

In view of the shortness of the time I must refrain from a more exhaustive discussion of this most interesting chapter of the contact bodies. It will be quite evident from what I have said that the industry has now a number of active contact bodies for the synthesis of ammonia at its disposal, and can select from case to case the most suitable.

Another discovery of first-class importance for the industrial application of the catalysis of ammonia was the recognition of the fact that there are special poisons, so to speak, for the reaction. That is to say, there are substances which hinder or prevent the reaction, although the contact mass does not suffer a noticeable chemical change, envelopment, or destruction. In the literature there was no indication whether there were poisons at all for the contact mass in the catalytic manufacture of ammonia, or what their nature would be. In actual manufacture such contact poisons were known only in the case of the catalysis of sulphuric anhydrid and even here only when platinum was used. When employing other contact bodies, such as iron oxid, or burnt pyrites, there was nothing known of contact poisons; on the contrary, it has even been shown that the presence of arsenic, which is a poison for platinum, has actually a favorable action when iron oxid is used as catalyst.

It has now been ascertained that some of the poisons in the syntheses of ammonia are of quite a different nature from those of the sulphuric acid process; they are for instance, sulphur, selenium, tellurium, phosphorus, arsenic, boron, or the compounds of these elements such as sulphuretted hydrogen, arsenic hydrid, phosphorus hydrid, as also many carbon compounds and certain metals of low melting point which can readily be reduced by hydrogen from their compounds, for example lead, bismuth and tin, which do not act catalytically. Oxygen-sulphur compounds, such as SO_2, which acts directly and smoothly in the sulphuric acid catalysis, are very poisonous. Extremely minute quantities of these bodies which are almost always present even in the purest commerical products or in the so-called pure gases, suffice to render the catalysts absolutely inactive or at least to diminish their action very seriously. Thus iron, for example, prepared from ordinary iron oxid with a content of one per thousand of sodium sulphate is, as a rule, inactive. Iron containing one tenth per cent of sulphur is generally quite useless, and even with one hundredth per cent is of very little use, although in appearance and when examined with the ordinary physical and chemical methods no difference at all can be detected as compared with pure iron.

The recognition of these facts gave rise to two problems:

(*a*) The preparation of contact masses free from poison or the removal of such poisons from them.

(*b*) Freeing the gases to be acted on catalytically from all contact poisons.

In order to free the contact bodies from these harmful substances, the ordinary methods for removing them can of course be applied. The contact action can also be improved by heating contact metals which are inactive or of little use, owing to the presence of contact poisons, in the presence of oxygen or of bodies yielding oxygen. Or the metals can be heated, for instance, in the presence of oxygen with the addition of suitable compounds such as bases, and the resulting products reduced. These operations can be repeated if necessary. If more of such a body as mentioned is added than is necessary, it may act not merely by removing the poisons, but promote the yield, as I have already described to you.

On the other hand it is necessary, as I remarked, to take the greatest care that nitrogen and hydrogen are free or freed completely from all contact poisons. Thus a trace of sulphur, one part per million, in the gas mixture can under certain conditions be injurious, so that even electrolytically prepared hydrogen must generally be further purified. The minute purification of the gases is even more important when hydrogen prepared, for example, from water gas is used. The impurities, too, taken up from iron piping play sometimes an important part, and impurities which get into the gases during the compression, such as machine oil, often have a harmful effect.

The best method of removing impurities from the gas mixture depends in turn on the nature of these impurities and consists, for instance, according to the case, in filtering, washing, conducting over solid absorption agents and so on. One good method is to bring the gases into contact with the material of which the contact mass is prepared at a raised temperature, before passing them over the actual catalyst. The material takes up the impurities, and must of course be renewed from time to time. The negative results of earlier investigators in the formation of ammonia when using base contact metals (Wright, Ramsay and Young, and, more recently again, 1911, Neogi and Adhicary), according to which nitrogen and hydrogen do not combine in the presence of iron, are in my opinion probably due, for the most part at least, to the use of metals or gases not free from contact poison. That previous inquirers had not the remotest idea that sulphur in the contact metal could be injurious, is evident from the fact that they passed the gases without hesitation through concentrated sulphuric acid in order to dry them. The sulphuric acid thus taken up and the sulphur dioxid often contained in it can poison even the best catalyst very speedily and render it unfit for use. Or the contact metals were sometimes prepared directly from the sulphates, although a metal sufficiently free from sulphur can scarcely be obtained by this method.

A painstaking study, for which we are indebted principally to Dr. A. Mittasch and which involved literally many thousands of experiments, has afforded an insight into the importance of substances of the most varied nature as promoters and poisons and thus a sure foundation has been prepared for a reliable continuous manufacture with a good yield of ammonia.

The question has not yet been touched upon in the foregoing, how the elements, nitrogen and hydrogen, which are requisite for the new ammonia process, can best be produced on a technical scale. Theoretically, the task would be unusually simple. If you remember that the terrestrial atmosphere according to the studies of A. Wegener and others consists of practically pure hydrogen at a height of about 120 kilometers, indeed at a height of about 70 kilometers consists of almost exactly one volume of nitrogen and three volumes of hydrogen besides a trace (about one half per cent) of oxygen, you will understand that all the conditions were given for an ammonia factory according to Jules Verne. For it would then merely be necessary to suck down the gases from the higher strata of the atmosphere by a sufficiently long pipe line.

For us, poor mortals, matters are not so ideally simple, for, as the poet says,

"hart im Raume stossen sich die Sachen."

Fortunately, however, there is no great difficulty in separating nitrogen from the air, either by physical means, according to Linde's process, or chemically, by removing the oxygen with glowing copper, burning hydrogen, or the like. And for the preparation of hydrogen in recent times a great deal of useful work has been done too, owing to the extensive growth of its field of application. In certain works it is at disposal in large quantities as a by-product of the electrolysis of common salt. Besides this it can be produced, for example, by passing steam over red-hot iron, or from water-gas, for instance, by separating its constituents hydrogen and carbon monoxid by cooling to a very low temperature. All the methods of preparation which come into consideration we have of course minutely examined; owing to the comparatively trifling differences in the cost of production various methods can be employed. At all events, both elements, nitrogen and hydrogen, are at the disposal of the new industry to any extent and sufficiently cheap.

As the production of these elements is not confined to the presence of cheap water power, all those countries where the manufacture of calcium nitrate, owing to the want of such power, is not practicable, as for instance in Germany, are now in a position to profit by the new industry. As I remarked at the outset, there is every reason to assume that this industry will find a fruitful field of employment in America, where the demand for nitrogen manures will soon be greater than hitherto.

CHILI SALTPETER.

Year.	Chilian Export.[1]	Price[2] per Ton. Marks.	Total Value. Mill M.	Increase.
1900	1,454,000	162.2	216.6	1901-11 995,400 tons
1901	1,274,000	172.8	..	that is an annual
1902	1,379,200	176.2	..	average of 99,500
1903	1,457,600	178.4	..	tons containing 15.5
1904	1,479,100	196.2	..	per cent, i. e., about
1905	1,652,200	204.8	338.2	15,400 tons nitrogen,
1906	1,731,800	215.0	..	valued at 19 million
1907	1,653,600	214.4	..	marks.
1908	2,052,400	193.3	..	
1909	2,133,900	184.5	393.7	First six months 1912
1910	2,334,000	177.6	..	150,000 tons valued
				at about 29 million
Jan.-June				marks as against
1911	(1,299,000[3])	..	..	corresponding period
1911	2,449,000	190.7	467.2	1911.
1912	(1,449,000[3])			

[1] According to the figures of the Association Saltrera.
[2] Annual average Hamburg quotations.
[3] Semi-annual deliveries in Europe.

AMMONIUM SULPHATE.

Year.	World Production. Tons.	Price per Ton. Marks.	Total Value. Mill M.	Increase.
1902	543,000	241[1]	131	1908-11 329,000 tons, i. e.,
1908	852,000	237	202	an annual average of
1909	978,000	230	225	110,000 tons, containing
1910	1,111,80)	248.5	276	20.5 per cent, i. e., about
		about		22,500 tons nitrogen,
1911	1,181,000	278	328	valued at about 30.6
				million marks.

[1] Quotations fob. Hull.

It can also be regarded as certain that the development of this new industry will not take place at the cost of other branches of industry and commerce. Bear in mind for a moment the present annual requirements for nitrogen manures and their continued growth. According to the tables these figures reached the remarkable total of 467.2 + 326, i. e., 793.2 million marks (about 189 million dollars) in 1911, and each year sees an increase. In the last few years the increased demand for ammonium sulphate amounted to about 10 per cent. The increase of production from 1910 to 1911 amounted to 69,000 tons, and from 1908 to 1911 on the average as much as 110,000 tons, or 110 million kilogrammes valued at about 30.6 million marks (7.3 million dollars). Similarly the nitrogen requirements of the world for manure purposes in the form of saltpeter is growing. Chili exported in 1908 about 2,052,400 tons of saltpeter, and already in 1911 the figure was about 2,449,400 tons, that is an annual increase of nearly 150,000 tons valued at approximately 29 million marks ($7,000,000). Indeed the European deliveries, according to the latest reports, from January to the end of June, 1912, reached as much as 1,449,000 tons, a demand which Chili was hardly able to meet.[17] The average annual increase from 1901 to 1911 amounted to 99,500 tons. That is to say, taking saltpeter and ammonium sulphate together and reckoning only the average increases, calculated on nitrogen, we have an annual increase in production of about 38,000 tons nitrogen, corresponding to nearly 185,000 tons of ammonium sulphate.

It can thus be seen that enormous quantities of synthetic ammonium sulphate must be produced to affect the total production by as much as one year. The saying so often applicable, that

"Das Bessere ist der Feind des Guten,"[18]

will thus probably have no meaning in this field. A peaceful development of the various new industries for the combination of the nitrogen of the air side by side is to be expected, and without encroaching at all on the previous production of nitrogenous manures, a favorable horoscope may be cast for a fortunate career for the new industry.

Antifreezing Solutions

A PROMINENT motor truck company has sent out the following antifreezing formulæ to its customers:

Thirty to 15 degrees above zero: Wood alcohol, 10 per cent; glycerin, 10 per cent; water, 80 per cent.

Fifteen to 8 degrees above zero: Wood alcohol, 12½ per cent; glycerin, 12½ per cent; water, 75 per cent.

Eight degree above to 10 degrees below zero; Wood alcohol, 25 per cent; glycerin, 12 per cent; water, 63 per cent.

Ten to 20 degrees below zero: Wood alcohol, 50 per cent; glycerin, 25 per cent; water, 25 per cent.

[16] Such conditions are, e. g., that tungsten, or its compounds mentioned, is prepared at temperatures not much above 600 deg. Cent., that they are prepared from tungsten compounds by means of ammonia, in which case there is no restriction to a temperature at about 600 deg. Cent.

[17] During the first six months of 1912 the production in Chili was roughly 10,000 tons less than in the corresponding period of 1911, and at the same time stocks in sight in that country receded by round 50,000 tons.

[18] Freely translated this might be rendered: "The only menace to a good thing is a better."

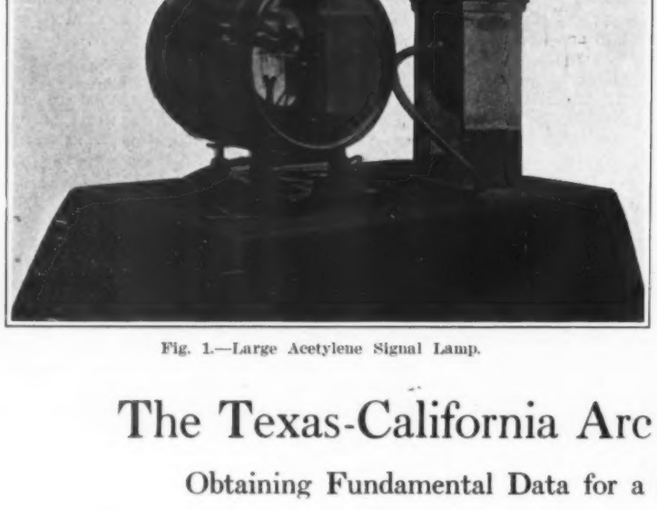


Fig. 1.—Large Acetylene Signal Lamp.

Fig. 2.—Small Acetylene Signal Lamp.

The Texas-California Arc of Primary Triangulation*

Obtaining Fundamental Data for a Geodetic Survey of the United States

By William Bowie, Inspector of Geodetic Work and Chief of the Computing Division, Coast and Geodetic Survey

GENERAL STATEMENT.

In September, 1907, the Coast and Geodetic Survey began the reconnoissance (selection of stations) for an arc of primary triangulation to extend westward from the line Kyle-McClenny of the ninety-eighth meridian triangulation in central Texas to the line Cuyamaca-San Jacinto of the Pacific coast primary triangulation in the

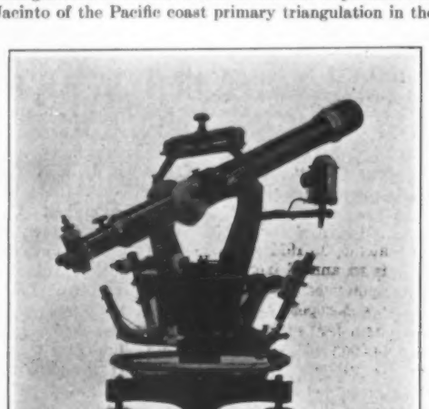


Fig. 3.—Twelve-inch Theodolite With Electric Light for Illuminating the Cross Wires.

southern part of California. The reconnoissance was ended in February, 1908. The erection of signals was begun at the eastern end of the arc immediately after the completion of the reconnoissance, and the observing began in the fall of 1908. The observing was done in three seasons and was completed in February, 1911. The observing party also measured the bases to control the lengths in the triangulation, and it observed such astronomic azimuths as were needed along this arc for geodetic purposes.

The length of the primary triangulation of this arc, along the axis of the scheme, is 1,207 miles (1,942 kilometers), and the length of subsidiary schemes, secondary in character, is about 70 miles (113 kilometers). The latitudes of the two stations already established in Texas from which the arc started are 32 deg. 49 min. and 32 deg. 27 min. The latitudes of the two old stations in California to which the new work was joined are 32 deg. 57 min. and 33 deg. 49 min. In longitude the arc extends from 98 deg. 12 min. to 116 deg. 41 min. The range in latitude is 3 deg. 58 min. The area in the main scheme is 49,220 square statute miles.

There were 115 stations occupied for horizontal observations, 92 in the main scheme and 23 in the subsidiary schemes.

The Texas-California arc has been completed with greater rapidity and at a lower cost than any previous arc of primary triangulation in this country. It probably has not been excelled in rate of progress or low unit costs in any other country.

RECONNOISSANCE.

The reconnoissance was done in one single season by a single party, which consisted of the writer, who was in charge; Signalman Jasper S. Bilby, who had previously had much experience in reconnoissance for primary triangulation, and a teamster. The equipment of the party consisted principally of five horses and mules, one freight wagon, one spring wagon, two riding saddles, two 9-foot center-pole tents, bedding for three men, a small amount of supplies and tools for making repairs, two draw telescopes, several binoculars and prismatic pocket compasses, a pocket tape line, a 4-inch transit with vertical circle, an odometer, and a small case of drawing instruments. Before going to the field copies of all Government and commercial maps were procured, as well as all available data relating to previous surveys in or near the area to be covered by the reconnoissance.

It was planned that the new triangulation should extend from a line of the ninety-eighth meridian primary triangulation, just to the westward of Weatherford, Tex.; follow the Texas & Pacific Railroad to El Paso, Tex.; cross the southern parts of New Mexico and Arizona as close as practicable to the international boundary, and then cross the State of California and connect with a line of the Pacific coast triangulation to the eastward of San Diego.

It was also planned that the new work should connect with existing triangulation by the United States Geological Survey, the California and Nevada boundary survey, the United States and Mexican boundary survey, and with monuments of the international boundary at El Paso, Tex., Nogales and Yuma, Ariz., and at other places where practicable.

The first 330 miles at the eastern end of the arc runs through a partly wooded, rolling country, with an occasional isolated butte or hill (usually flat topped). In this section it was necessary to elevate the instrument at most of the stations. To the westward of the stations Ingle and Sist the country was mountainous and no structures were needed for elevating the instrument except at the Deming base.

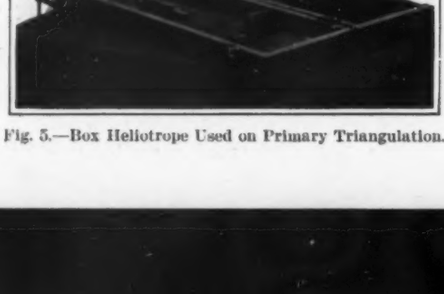


Fig. 5.—Box Heliotrope Used on Primary Triangulation.

During the first part of the season the party remained together and the writer and Mr. Bilby went out from the camp together to nearly all of the selected stations. During the greater part of the season the party operated in two separate sections; the writer, with a saddle horse,

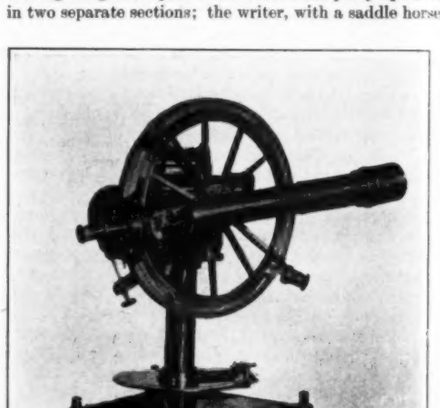


Fig. 4.—Vertical Circle Used in Trigonometric Leveling and for Making Time Observations.

teamster, and freight wagon, while Mr. Bilby used a spring wagon. After dividing, the party met only at Sierra Blanca, Tex.; El Paso, Tex.; Hermanas, N. Mex.; Tucson, Ariz.; and Yuma, Ariz. At each of these places the scheme was adopted from the stations located by the two observers.

No day or night signals of any kind were used during the entire season. The success of the reconnoissance is attested by the fact that no reconnoissance station was abandoned during the subsequent triangulation. One station was moved about one half mile on a flat-topped ridge in order to avoid elevating the instrument 16 feet, and the north end of the Deming base line was moved northward about 2 miles to improve the base net. In only a few cases was it necessary to elevate the instrument more than planned by the reconnoissance.

In the following table are given in condensed form the data regarding the progress and cost of the reconnoissance for the Texas-California arc. The cost includes all salaries, even that of the chief of party while at the office preparing for field work and after his return from the field while making out his final report on the reconnoissance. The cost also includes 25 per cent of the cost of five horses and mules and two wagons which were used

* Special Publication No. 11 of the *Coast and Geodetic Survey.*

about twenty months on this arc by the building and observing parties and only about five months by the reconnoissance party. In this table only the stations, the area, and the length of the main scheme are considered, although subsidiary stations located added to the total cost of the season.

STATISTICS OF RECONNOISSANCE.

Date of beginning actual field operations	Sept. 17, 1907
Date of ending actual field operations	Feb. 8, 1908
Total length of season by months	4.07
Cost of work, including salaries	$4,855
Number of principal stations selected	92
Length of main scheme in miles	1,207
Area in main scheme, in square miles	49,220
Cost per station selected	$53.00
Cost per mile of progress	$4.02
Cost per square mile covered	$0.10
Progress in miles per month	260

SIGNALS.

The signals used on the Texas-California triangulation were similar to those used on the greater portion of the ninety-eighth meridian triangulation, which are described in detail in Appendix 4 of the Report for 1903. Fig. 6 is taken from that report. When only one observing party is operating, as was the case on the Texas-California arc, the top platform shown on the signal in Fig. 7 is omitted. The superstructure shown on the signal in illustration Fig. 6 is used to elevate the heliotrope and lamp at each end of an obstructed line. Signals at nearly all of the stations occupied during the first season were erected during the spring and fall of 1908 and before the beginning of the observing. Several signals were erected just before the close of the first observing season.

During the spring of 1908 36 signals of an aggregate height of 1,015 feet (309 meters) were erected at a total cost of $3,600. This includes the material for station and reference marks and the cost of putting them in place. This made the cost per vertical foot $3.55.

PROGRESS OF OBSERVING.

Season of 1908–9.

In addition to the chief, the observing party during the first season consisted of Signalman Bilby, a recorder, and a teamster. The camp equipage and means of transportation were practically the same as were used in the reconnoissance. With a light outfit quick moves could be made between stations, and the work about camp was reduced to a minimum. The members of the observing party lived in the tents and, wherever practicable, obtained board at farm and ranch houses. Where this was not convenient, a small emergency cooking outfit was used by the party in preparing meals.

The observing was done entirely on heliotropes and acetylene signal lamps. The usual form of heliotrope is shown in Fig. 5. The lamp used on most of the Texas-California triangulation is shown in illustration Fig. 1. The smaller lamp, used on nearly all the ninety-eighth meridian triangulation and at a few stations of the new triangulation, is that shown in illustration Fig. 2.

Five light keepers were used by the triangulation party, and they were directed by letter and by code signals, sent in a modified Morse alphabet, using the lamps and heliotropes in signaling. The light keepers lived in tents, prepared their own meals, and moved from station to station with teams hired for the individual trips. Each was supplied with a sketch of the triangulation and also with descriptions of the stations. They had no difficulty in moving from station to station, and only in rare instances did they have any trouble in getting the direction to the observer's station. With few exceptions, the same men were retained as light keepers throughout the season. It is essential to rapid progress to have a trained corps of light keepers who can operate without assistance from the observing party.

The country traversed during the first season was rolling, with occasional hills standing well above the general level of the country. The average length of the lines of the triangulation was about 15 miles (24 kilometers). The land was partially settled and the roads were fair. Very little difficulty was encountered in getting water for the party and stock.

Season of 1909–10.

The second season's observing began on September 7th, 1909, at the station Toyah, Tex., and ended at the Deming base net, New Mexico, on January 7th, 1910. Owing to the fact that the country to be worked over was arid, mountainous, and with few settlers, a somewhat different organization of party was used during this season.

The observing party consisted of the chief (who was the observer), a recorder, and a teamster. The camp equipage was reduced to a minimum. Seven heliotropers or light keepers were employed throughout the season. They were usually posted by the signalman and his assistant, who also prepared the stations for the observer and set the station marks. When a light keeper took a station he remained there until all observations on that station were completed. He was also at the station and assisted the observing party while the station was occupied for observations. The movements of the light keepers were, as usual, directed by signaling. When each of the light keepers was through with his work at a station he was moved to the nearest railroad station by a teamster, who was employed throughout the season for that purpose, and the light keeper traveled by train ahead of the observer and was posted as noted above. The teamster, whose work it was to move the rear light keepers to the railroad, usually communicated with the men on the mountain peaks by signaling with a heliotrope or lamp.

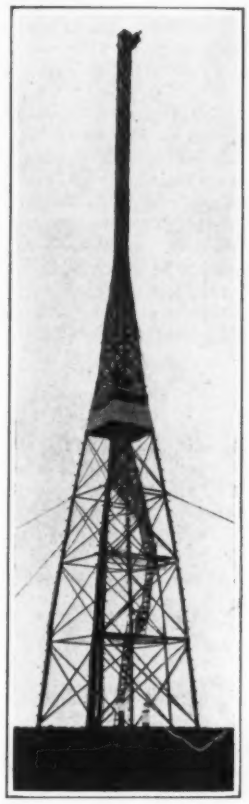


Fig. 6.—Signal at Burson on the Ninety-eighth Meridian Triangulation.

Fig. 7.—Sixty-foot Signal.

It was found to be necessary in most cases to haul water to the stations for the light keepers. As a rule, when he was posted, enough could be taken to a station to last until the observing party reached the station. Each of the several freight wagons was equipped to carry about 70 gallons of water in specially constructed cans. These cans were fastened to the outside of the wagon.

The camp equipage of the observing party and of the light keepers was taken to the station, or some point near it, by pack mules or horses. It was only occasionally that any hand packing was done.

At the end of the season the party measured the Deming base with invar tapes.

Season of 1910–11.

At the close of the second season's work there remained to be done about 600 linear miles of the arc. The stations at the eastern end of this section in New Mexico and Arizona are on high mountain peaks, and the three stations at the extreme western end of the section are also on high mountains. It was desired that all of this section be done in one observing season, and in order to do this the high mountain stations must be occupied during the summer months in order to avoid the snows of the early fall. The plan adopted and carried out was to complete the observations first at the stations forming the extreme western quadrilateral of the arc, then return to the vicinity of the Deming base net and work westward through the remainder of the scheme. The last one of the high peaks (Catalina) was occupied on November 1st. The observations for this season began on July 6th, 1910, and they ended on February 22nd, 1911. Neither the observing party not the light keepers were seriously interfered with by snow during the season.

The organization and equipment of the party were the same as those of the preceding season and the management of the work was not changed in any material way.

METHODS OF OBSERVING EMPLOYED.

The observations for the primary horizontal angles were made in accordance with the General Instructions for Primary Triangulation.

All the horizontal angle measures were made by the direction method, using the 12-inch (30-centimeter) theodolites made in the Instrument Division of the Survey, one of which is shown in Fig. 6. The telescope used has a clear aperture of 61 millimeters and its focal length is 74 centimeters. The circle is graduated to five-minute spaces and is read by the micrometer microscopes to single seconds.

The telescope of the theodolite has two parallel vertical wires, about 20 seconds apart, for making the pointings for horizontal angles. The results from a number of seasons' work indicate that this arrangement of the wires in the telescope is more satisfactory than either the single vertical wire or the oblique cross. The double wire is especially effective when the image of the light or heliotrope is large and unsteady.

In making the measurements of horizontal directions each direction in the main scheme was measured 16 times. A direct and reverse reading was considered one measurement, and 16 positions of the circle were used.

When a broken series was observed, the missing signals were observed later in connection with the chosen initial or with some other one, and only one, of the stations

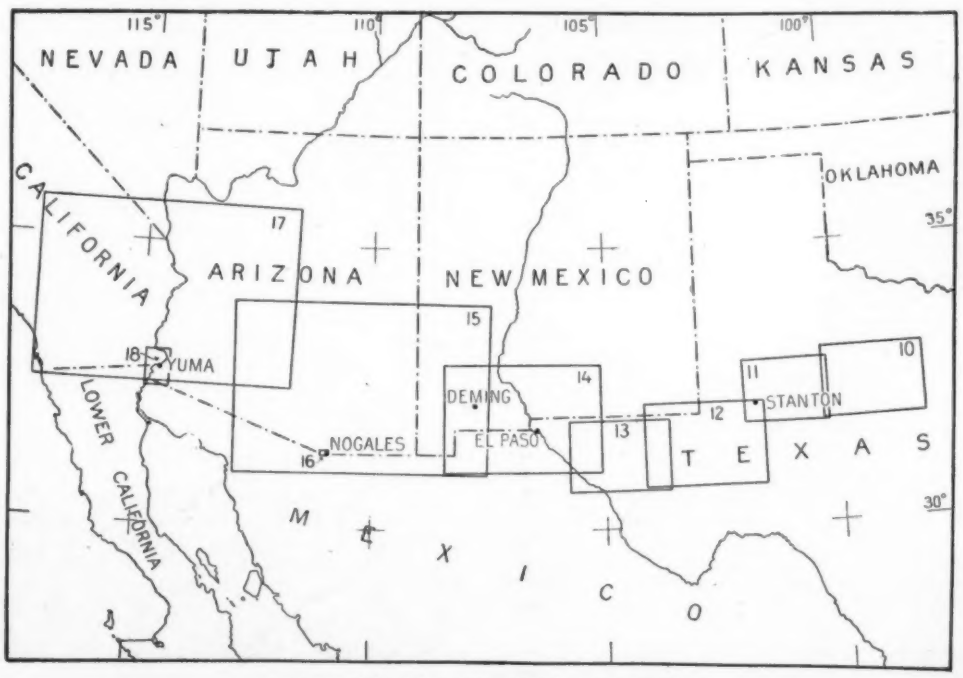


Fig. 8.—Index Map of the Territory Traversed.

already observed in that series. With this system of observing no local adjustment was necessary. Little time was spent in waiting for the doubtful signal to show. If it was not showing within, say, one minute of when wanted, the observer passed to the next. A saving of time results from observing many or all of the signals in each series, provided there are no long waits for signals to show, but not otherwise.

In selecting the conditions under which to observe primary directions the observer proceeded upon the assumption that the maximum speed consistent with the requirement that the closing error of a single triangle in the primary scheme shall seldom exceed three seconds, and that the average closing error shall be but little greater than one second, was what was desired rather than a greater accuracy than that indicated with slower progress. This standard of accuracy used in connection with other portions of the general instructions defining the necessary strength of figures and frequency of bases will in general insure that the probable error of any base line, as computed from an adjacent base, is about 1 part in 88,000 and that the actual discrepancy between bases is always less than 1 part in 25,000.

The limit for rejection of observations upon directions in the main scheme was 5 seconds from the mean. No observation agreeing with the mean within this limit was rejected unless the rejection was made at the time of taking the observation and for some other reason than simply that the residual was large. A new observation was substituted for the rejected one before leaving the station, if possible, without much delay.

The number of observations at supplementary stations and on intersection stations, as well as the number of vertical angle observations, conformed to the requirements of the General Instructions. It is not necessary to specify them here.

CONNECTIONS MADE WITH STATIONS PREVIOUSLY ESTABLISHED.

The Texas-California primary triangulation connected with the triangulation of the United States Geological Survey near the eastern end of the arc on stations Hitson, Wasp, Abilene standpipe, and Cisco astronomic station; also in western Texas at stations Newman, Diablo, Quitman, Cerro Alto, and North Franklin; in New Mexico on stations Line and Corduna; in Arizona with stations Graham, Baldy, Benedict, Huachuca, Mule, Burro, Superstition, and Maricopa northwest base; and in California with stations American and Picacho.

Connections were made with the triangulation of the United States and Mexican Boundary Survey at El Paso, Nogales, and Yuma. Besides the monuments at each of those three places, international monuments Nos. 31, 32, 39, 40, and 91 were connected with the triangulation.

A connection with the triangulation of the California-Nevada boundary was made near Needles, Cal.

Investigations of Chemical Reactions at High Pressures

By the Berlin Correspondent of the Scientific American

THE application of high pressures must influence the course of chemical reactions in a number of ways. In gaseous systems increased pressure brings with it increased concentrations, and hence increased reaction velocity. At the same time the point of equilibriumis in general changed in favor of the formation of the products having a smaller volume. In the case of liquid reagents one of the most important effects of high pressure is to render available high temperatures, owing to the rise in boiling point with pressure.

Dr. F. Bergius[1], lecturer at the Hanover Technical University, has perfected an apparatus which, though comprising more than ten joints and closures, allows a pressure of 150 atmospheres to be kept up for 20 days at temperatures of upward of 300 deg. Cent. With this apparatus he, for instance, investigated the decomposition of calcium peroxide, and succeeded in producing this compound by synthesis from lime and oxygen.

With a similar apparatus he, in conjunction with his assistant, Mr. Spech, then investigated some reactions of water heated far beyond its ordinary boiling point. He was thus in a position to show the possibility of burning carbon with liquid water heated close to its critical point about 360 deg. Cent.), thus forming carbonic acid and hydrogen. The water, containing in solution various catalyzers, was made to act on charcoal or coke in an iron bomb, which, being covered with an oxide layer, was not affected by the water. The hydrogen and carbonic acid thus obtained by combustion were found to bear to one another a ratio approximately corresponding to theory.

In other experiments the water heated beyond its boiling point was not itself one of the re-agents but, as it were, served as heat accumulator. These interesting experiements were intended to reproduce the natural process of coal formation. If certain organic materials, such as wood, peat, etc., be heated to charring in an air-tight vessel, the temperature rises spontaneously above that of the external source, the decomposition of cellulose being attended by production of heat. This is why all previous attempts in this direction failed to produce coal of the same composition as pit coal, the spontaneous heating resulting in a partial coking of the materials.

If we wish to produce in our laboratories in a short time and at high temperatures the same process as carried out by Nature in millions of years at ordinary temperatures, means should be provided to remove any excess of heat from the point of reaction. Liquid water in intimate contact with the substance to be charred was found to provide the means for such regulation of temperature. Owing to its high heat capacity, water absorbs any surplus heat produced in the disaggregation of cellulose. Peat heated in high pressure vessels in its natural condition, i. e., with 85 per cent of water, or else pure cellulose mixed with much water, was used in these experimenta. The gases evolved in the charring process, which consist of carbonic acid and methane, containing about 12 per cent of the total carbon, were analyzed after the experiment. The coal products obtained at different temperatures and after more or less prolonged reaction were found to be of extremely variable composition. The higher the temperature, the more oxygen was evolved in the form of carbonic acid, and the greater were the carbon contents of the artificial coal. The composition of the coal obtained at 340 deg. Cent. coincides with that of natural fat coal.

As in most reactions it was found that the velocity of this reaction approximately doubled for every 10 deg. Cent. rise in temperature. Thus for an increase of 30 deg. Cent, the reaction velocity would be multiplied $2^3 = 8$ times. This allows us to form some estimate of the time which would have been required for producing the same coal at the temperature of the ground. Supposing the average temperature of natural coal formation to be in first approximation 10 deg. Cent., a period of about 7 to 8 million years would, it is found, have been required to produce natural fat coal. This figure agrees fairly well with those adopted by geologists.

[1] Zeitschr. f. Elektrochemie, No. 15, 1912.

China Suppressing the Opium Habit

THE establishment of the Chinese Republic has led many occidentals to change their settled opinion as to the deadly lethargy of spirit and the absolute inertia which they supposed characteristic of the inhabitants of the Celestial Empire. There is another story of accomplishment in China, however, during the past five years, which makes it even clearer than the recent revolution that there are undreamed of springs of energy in the character of the Chinese people. About five years ago the Chinese government decided that opium-smoking, which had become the national vice of China even to a greater extent than alcoholism is of the Western nations, must stop, and that within ten years. It is scarcely to be wondered at that when this government edict was issued it was greeted with smiles everywhere; ten years seemed entirely too short a period to set for any such reformation, at least two or three generations appearing more reasonable. Scarcely any one dared to hope for success and it seemed beyond all doubt that China had entered on an impossible task. Five years have passed of the ten-year period, and now the world knows that China has already achieved great things and that success in the great national crusade seems almost assured.

The method that China is pursuing will interest particularly those who are concerned with similar problems of the abuse of stimulants and narcotics and who are thinking of the possibility of eradicating even national vices. Five years ago China and Great Britain made what is known as "the ten years' agreement," by which the British government undertook to reduce the amount of opium sold in Calcutta on government account for export to China by 10 per cent every year until the traffic had ceased. On her part China agreed to diminish her own production in a corresponding way. Measures were to be taken to reduce the growth of opium in China 10 per cent each year until at the end of ten years no more would be raised. With supplies from India cut off and the home crop reduced and eventually suppressed altogether, the opium habit must necessarily disappear. The results accomplished thus far are promising, which is all the more remarkable because nearly every one prophesied failure, and the very missionaries who had carried on the crusade against opium for years sadly shook their heads, feeling that the great problem could not be solved in this simple way.

Travelers report that it is no longer common, as it was formerly, to see men smoking opium at their own doors. Even two years after the edict, those who smoked did so in secret. Dr. Cantlie quotes Lord William Gascoyne-Cecil in his fascinating book "Changing China," who tells of the extraordinary difference that even two years made in the aspect of the land. On his first visit the country between Hankow and Harbin, as seen from the railway, was exquisite with the pink and white crops of poppy. On his next journey, nearly two years later, every poppy had disappeared. The edict is being enforced. The agricultural map of China shows after five years that there has been an actual reduction of 50 per cent in the production of opium. There has been as great a reduction in its use. This has been accomplished in spite of the fact that there were serious economic difficulties in the way. The small farmer nearly everywhere throughout China took up the cultivation of the poppy as a valuable "side line." Many grew only as much rice and as many vegetables as they used themselves; opium was the only product raised for the market. Opium is easily transported. A farmer could put the whole product of several fields on his back and sell it readily and profitably. The government deprived him of this source of income and the result has been a most favorable development in agriculture. In Yunnan, the province which formerly had the largest proportion of poppy growth, opium has given way to silk and cotton cultivation. In other districts the production of cereals has increased enormously. Particularly rice cultivation has grown in amount. Rice used to be imported, but enough is now raised in Chinese provinces to reduce the importation by several millions of dollars' worth.

All the world will watch with interest this other awakening of China, and the Oriental method of solving a great social question. In the West we have our social problems of a similar nature and China's example may prove illuminating and helpful.

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